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TABLE OF CONTENTS

Vol. 21 July, 1938 No. 7

THE JOURNAL

The Life History of a Glaze: I, Maturing of a Whiteware Glaze 239
By A. M. Blakely

The Life History of a Glaze: II, Measurement of Stress in a Cooling Glaze 243
By A. M. Blakely

The Effect of Different Bodies on Some Wetting and Flow Characteristics of Glazes 252
By C. M. Lampman

Fourier Analysis of X-Ray Patterns of Soda-Silica Glass 259
By B. E. Warren and J. Biscoe

CERAMIC ABSTRACTS

17—7

Abrasives 239
Art and Archeology 242
Cements 244
Enamel 245
Glass 246
Structural Clay Products 252
Refractories 253
Terra Cotta 255
Whiteware 257
Equipment and Apparatus 257
Kilns, Furnaces, Fuels, and Combustion 259
Geology 261
Chemistry and Physics 263
General 265

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LIFE HISTORY OF A GLAZE: I, MATURING OF A WHITEWARE GLAZE*

By A. M. Blakely

Abstract

Glazed specimens of a commercial semivitreous body were fired according to a production tunnel-kiln schedule, and draw trials were taken out and quenched at frequent temperature intervals. Thin sections of these specimens were examined with a petrographic microscope for a determination of the constituents in the glaze and at the interface. The volume of the bubbles, undissolved feldspar, and undissolved quartz were measured for each temperature.

I. Introduction

To understand fully the mechanism of the maturing of a glaze, the reactions that occur in the glaze itself and the reactions between the glaze and the body must be known. It is particularly necessary to know the relative solution rates of the glaze constituents in the resultant glass, the bubble formation and elimination, the reaction products of this glass and the body, and the stresses set up in the glaze on cooling. In Part I of this paper, the reactions of the glaze on heating are treated; in Part II the stresses in cooling are considered.

II. Body and Glaze

The work was carried out on a commercial, semivitreous whiteware glaze and body which had shown satisfactory service. The compositions are as follows:

Complete glaze

$$\left.\begin{matrix}0.115\ Na_2O\\ .111\ K_2O\\ .333\ PbO\\ .446\ CaO\end{matrix}\right\} \left\{0.346\ Al_2O_3 \left\{\begin{matrix}3.10\ SiO_2\\ 0.308\ B_2O_3\end{matrix}\right.\right.$$

Fritted portion

$$\left.\begin{matrix}0.034\ Na_2O\\ .020\ K_2O\\ .050\ PbO\\ .360\ CaO\end{matrix}\right\} \left\{0.042\ Al_2O_3 \left\{\begin{matrix}0.846\ SiO_2\\ 0.308\ B_2O_3\end{matrix}\right.\right.$$

Body

Ball clay	33
Kaolin	20
Flint	36
Feldspar	11

III. Preparation of Specimens

To study the reactions taking place in the maturing glaze, small round tile, $^1/_2$ by $^1/_{16}$ inch, were prepared by stamping a thin plastic layer of the body with a brass die. These were dried and biscuited to the maturing temperature of the body (1220°C). The resulting tile were laid on a board and sprayed with the glaze to a uniform thickness, after which they were ready for the maturing study.

After several trials, it was decided to fire the tile on a commercial tunnel-kiln schedule.[1] With this fire, the final ware should closely approximate a commercial product. The specimens were withdrawn at various stages in the temperature rise and were air-quenched to preserve the phases present. Thin sections were then prepared from them and studied petrographically.

IV. The Mechanism of Maturing

It should be recalled that the glaze as applied consists of a finely ground mixture of glass (frit), feldspar, flint, white lead, clay, and whiting. This mixture at the start would have a porosity of about 30%, but as early as 600°C the frit will soften and reactions will occur with the other ingredients, thus reducing the porosity.

No specimens were withdrawn from the kiln under a temperature of 750°C, for below this the glaze was too fragile to make a good section. The first three photomicrographs (Figs. 1 to 3) show a section of a tile, quenched at 750°C, taken under 360× magnification, with and without crossed-nicols, and also under 80× magnification. From Figs. 1 and 2, it is evident that there is not enough glass to show any bubbles; instead, there are large holes or pores which can be seen at the left and upper center of Fig. 1. The holes are evidently the remains of spaces between the particles in the raw glaze. Figure 3 does not show them as well but gives an idea of their size and distribution.

At 750°C, the grains of quartz and feldspar give good interference figures and can be deter-

* Parts I and II presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 31, 1938 (General Session, Symposium on Glazes). Received January 17, 1938.

This material is abstracted from a thesis submitted in partial fulfillment of the requirements for a degree of Doctor of Science in the field of Ceramics at the Massachusetts Institute of Technology, Cambridge, Mass.

[1] V. J. Roehm, "Notes on the Operation of Direct-Fire Tunnel Kilns," *Jour. Amer. Ceram. Soc.*, **8** [8] 514–24 (1925).

FIG. 1.—Quenched at 750°C (magnification ×80).

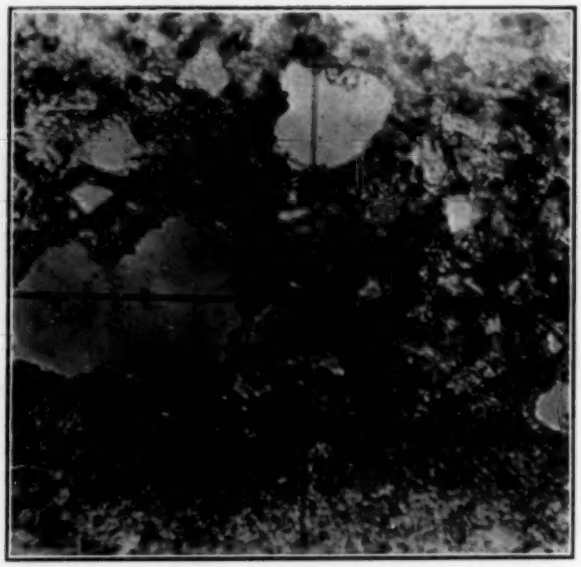

FIG. 3.—Quenched at 750°C (magnification ×360).

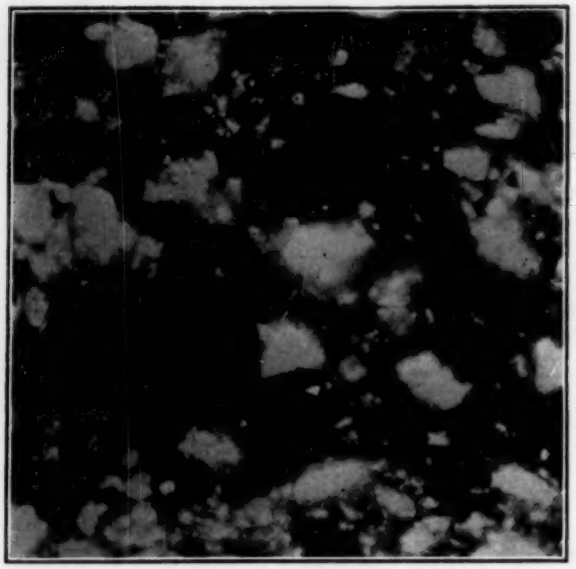

FIG. 2.—Quenched at 750°C; crossed-nicols (magnification ×360).

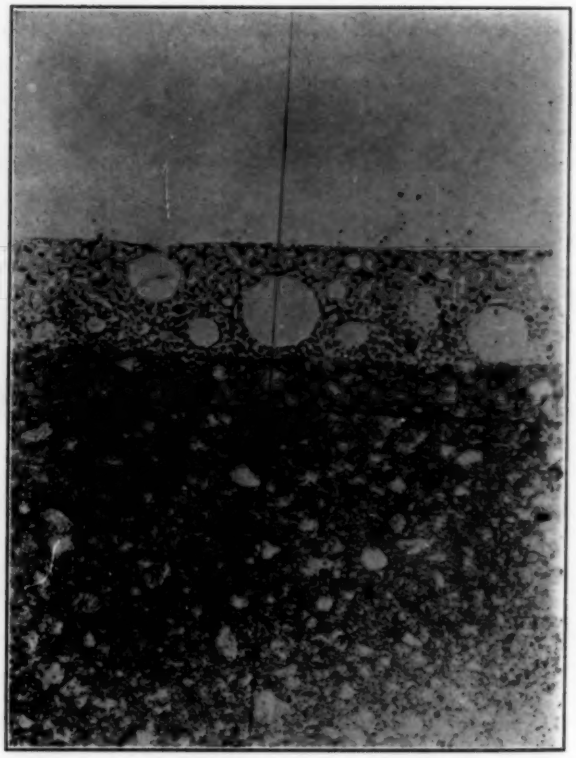

FIG. 4.—Quenched at 900°C (magnification ×80).

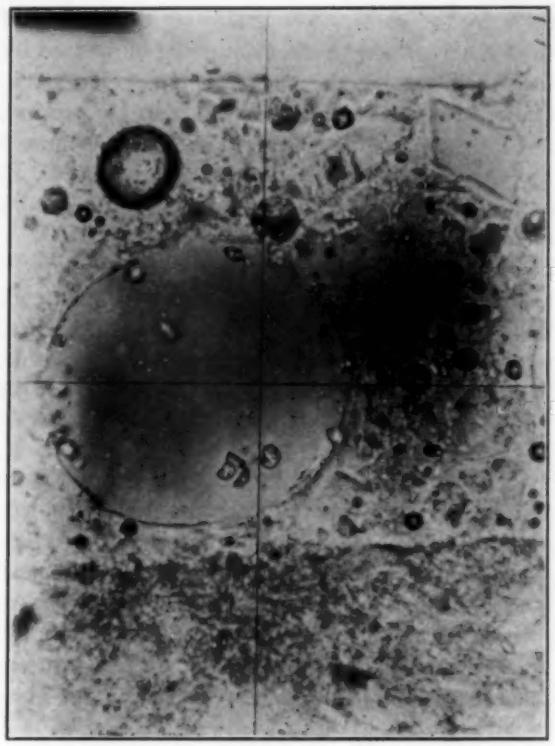

FIG. 5.—Quenched at 900°C (magnification ×360).

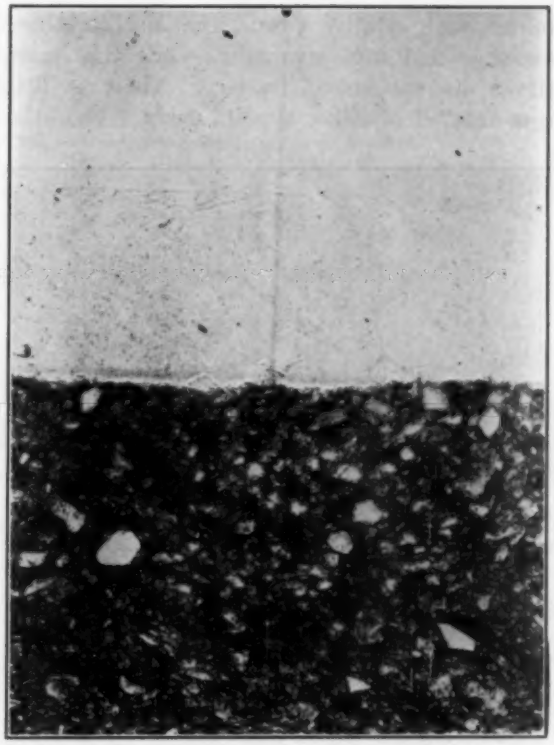

FIG. 7.—Quenched at 1095°C (magnification ×80).

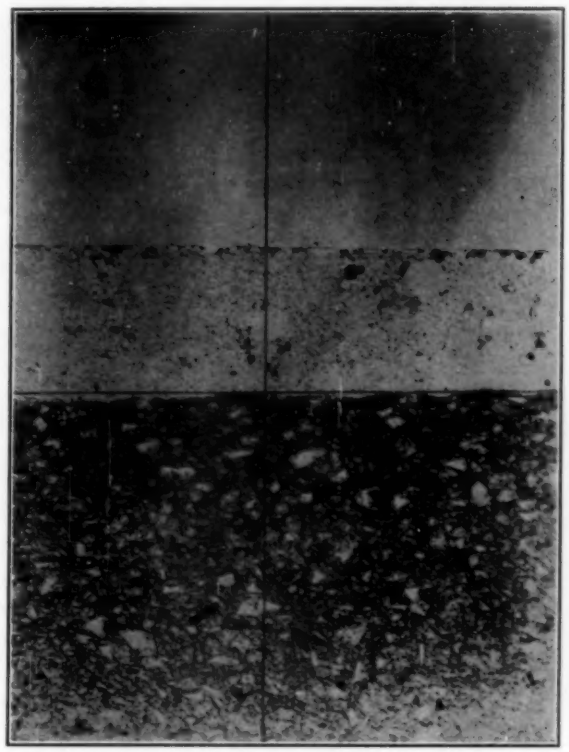

FIG. 6.—Quenched at 1025°C (magnification ×80).

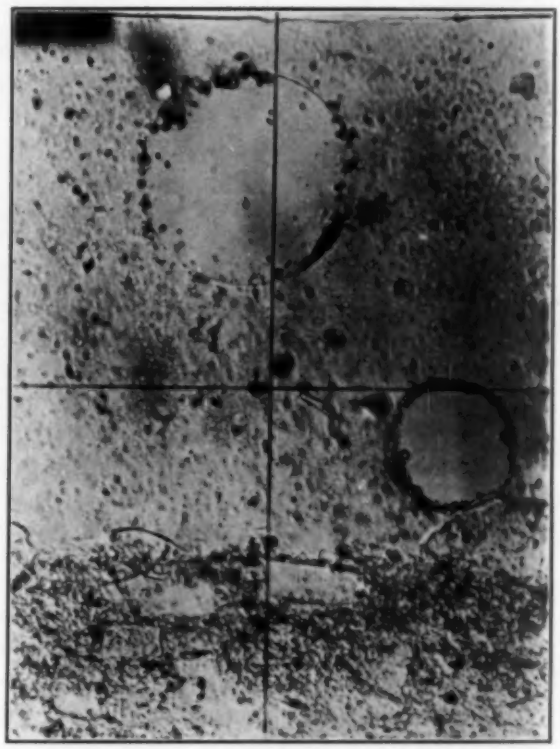

FIG. 8.—Quenched at 1145°C (magnification ×360).

mined with relative ease. The feldspar shows cleavage and some twinning, while the quartz shows its conchoidal fracture. There is little rounding off of either type of grain. The other components of the original glaze were too fine grained to be determined with any degree of accuracy. The fuzzy outline in Fig. 1 might be attributed to the clay.

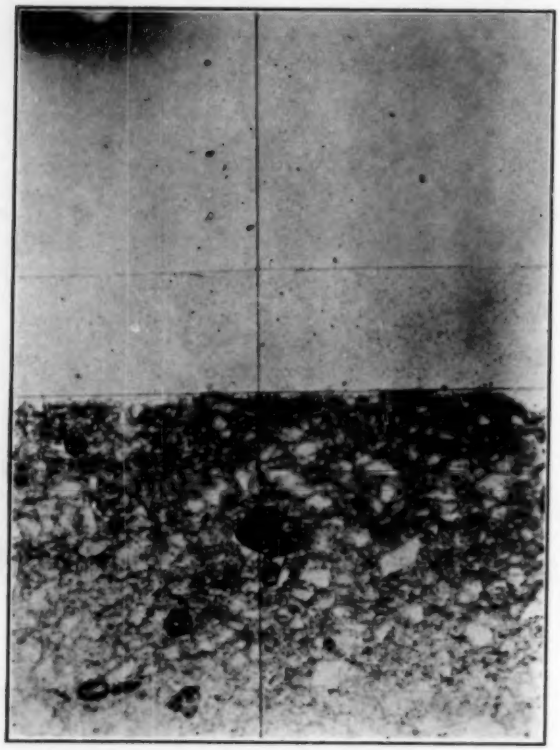

FIG. 9.—Quenched at 1150°C (magnification ×80).

The specimen, quenched at 900°C (Figs. 4 and 5), plainly shows the boundary between the body and glaze. Although there has not been much reaction between the two, the holes which were evident in Fig. 3 have completely disappeared. Figures 4 and 5 show that the large holes have finally taken shape and have formed into spherical bubbles. In the northeast quadrant near the surface of the glaze, a feldspar grain can be seen which is being dissolved by glass creeping into its cleavage cracks.

Figure 6 (1025°C) and Fig. 7 (1095°C) show that there is little crystalline material remaining above 1000°C. The latter indicates that most of the air bubbles have escaped at 1095°C. Figure 8 (1145°C) gives an idea of the erosion of the body by the glaze. The grains on the surface of the former show a marked rounding off caused by their solution in the molten glaze. The pockmarks are due to abrasive grains in the section, not to any inhomogeneity of the glaze. Figure 9 is a picture of the matured glaze. At 1150°C, all of the bubbles have had a chance to escape and a clear glass has resulted.

To obtain an idea of the degree of solution of the quartz and feldspar and also of the rate of bubble formation, particle counts of the three were made to determine their relative volume. These results are shown in Fig. 10.

V. Conclusions

(1) The bubbles in the glaze are derived from the interstices between the particles of the raw glaze. They are formed around 900°C when there is enough glass to allow them to take shape.

(2) At higher temperatures, there is a marked erosion of the body by the glaze. This may enable an interfacial layer of body dissolved in the glaze to be formed, which would allow the glaze to withstand thermal shocks more readily.

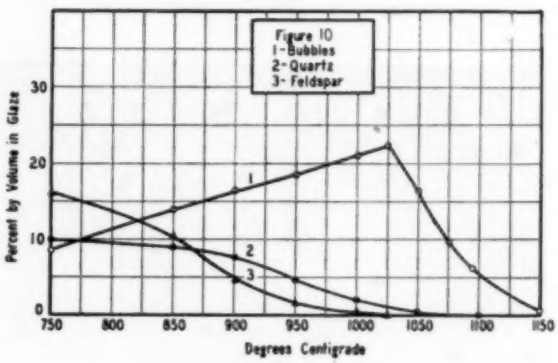

FIG. 10.

(3) The quartz in the glaze is dissolved completely at 1100°C, and the feldspar is dissolved at 1025°C.

(4) The bubble volume shows a maximum at 1025°C. This indicates that few bubbles escape below that temperature. The increase in volume between 750° and 1025°C is probably due to the thermal expansion of the air. The rapid decrease above 1025°C shows that the glaze is then fluid enough to allow them to escape.

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LIFE HISTORY OF A GLAZE: II, MEASUREMENT OF STRESS IN A COOLING GLAZE

By A. M. Blakely

Abstract

A modification of the Steger method is described for measuring the stress in a glaze. The test specimen consists of a double-pronged fork glazed on the outside so that the distance between the ends of the prongs gives a measure of the glaze stress. A method has been devised to calculate the actual stress in the glaze from the deflection of the prongs. Actual stress curves are given for several body combinations when the specimens are cooled, and the influence of aging and treatment in the autoclave is discussed.

I. Introduction

Many methods have been developed for measuring the stresses set up in a cooling glaze which is in contact with a ceramic body. Most of these have been used for plant control work and are qualitative rather than quantitative in scope. The method upon which this part of the work is based was developed by Steger[1] in Germany. It is more fundamental than any of the others and can be converted into a powerful quantitative tool for the measurement of glaze stress. Several improvements have been made here on Steger's original design to facilitate the ease of measurement and calculation of stress.

Steger's specimen consisted of a long strip of ceramic body 20 by 3 millimeters and about 200 to 300 millimeters long. One of the wide surfaces was covered with the glaze to be tested, and the piece was fired to mature the glaze. The specimen was passed through the core of a small cylindrical wire-wound furnace and fastened at one end to form a cantilever beam. The free end could thus move up or down as the temperature changed. The deflection was measured by a small, short-focus telescope with a micrometer eyepiece. Deflections in one direction meant that the glaze was in compression, while those in the opposite direction meant that it was in tension. Thus a continuous curve could be made of stress magnitude *versus* temperature.

II. Measurement of Stresses

Instead of using a specimen similar to Steger's, this work was carried out on one shaped like a tuning fork. The latter was made up by cementing two bars of extruded whiteware body to a short piece of the same material with slip (Fig. 1). Such a specimen has the obvious advantage of being complete in itself. If the difference between the free ends of the bars is taken as a measure of the stress in the glaze, a slight motion of the support will not affect the reading. The specimens can then be removed and returned to the furnace as often as desired.

The specimens were biscuit-fired to maturity and then the outside faces were sprayed with a uniform coat of glaze. They were glost-fired according to the tunnel-kiln schedule in Part I and were hung in the test furnace (Fig. 2). This furnace consisted of a platinum-wound tube set in high-temperature insulating refractories. Separate end coils permitted a temperature uniformity over the length of specimens of less than ±2°C.

Reference points of refractory cement were placed on the inside faces of the ends of the specimen so that the difference between them could be read with a short-focus telescope sighted through the window in the furnace. The furnace was then heated to such a temperature as to soften the glaze. To obtain a stress curve, the furnace was shut off, and readings of deflection *versus* temperature were taken as the temperature dropped to room temperature in a period of about twelve hours.

Specimens were made up with body B and glaze B (as described in Part I) and with another quite similar body H and glaze H that had shown bad crazing.

III. Calculation of Stress

Because it is assumed that both the glaze and the body are homogeneous, isotropic, and obey Hooke's law, the stress in each will be a straight-line function of y (Fig. 3). The equations are as follows:

$$Sx = A + By \text{ (body stress)} \quad (1)$$

$$Sgx = \quad + Dy \text{ (glaze stress).} \quad (2)$$

[1] W. Steger, "Measuring Stress in Fired Ceramic Ware," *Ber. deut. keram. Ges.*, **9** [4] 203–15 (1928); *Ceram. Abs.*, **7** [9] 625 (1928); also *Ber. deut. keram. Ges.*, **11** [3] 124 (1930); *Ceram. Abs.*, **10** [6] 437 (1931).

Values of B and D can be found in any book on applied mechanics and are $B = E/R$ and $D = Eg/R$.

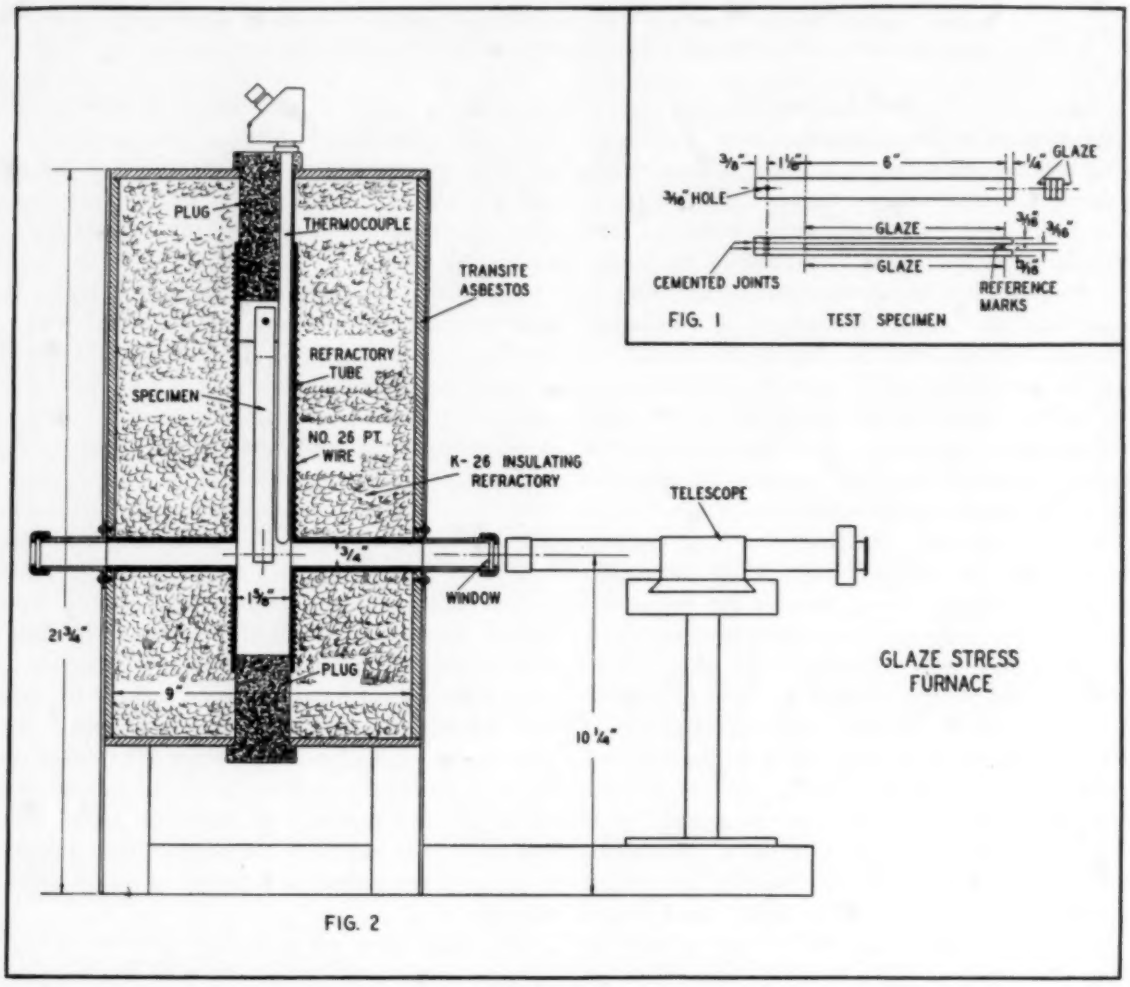
E and Eg = moduli of elasticity of body and glaze, respectively.

R = radius of curvature of beam (R will have essentially the same value for both the body and the glaze, inasmuch as the deflections are small compared with the length of the beam.)

$$\int_o^a Sx\,y\,dy + \int_a^b Sgx\,y\,dy = 0;\ \Sigma \text{ moments} = 0. \quad (6)$$

The integrals reduce to the following equations:

$$Aa + \frac{Ea^2}{2R} + C(b - a) + \frac{Eg}{2R}(b^2 - a^2) = 0. \quad (7)$$



FIGS. 1 AND 2.

The equations now become

$$Sx = A + \frac{E}{R}y. \quad (3)$$

$$Sgx = C + \frac{Eg}{R}y. \quad (4)$$

Because the beam is in equilibrium, the sum of all the forces about Oy must equal zero, and the sum of all the moments about O must also be equal to zero. In the language of calculus, this is

$$\int_o^a Sx\,dy + \int_a^b Sgx\,dy = 0;\ \Sigma \text{ forces} = 0. \quad (5)$$

$$\frac{Aa^2}{2} + \frac{Ea^3}{3R} + \frac{C}{2}(b^2 - a^2) + \frac{Eg}{3R}(b^3 - a^3) = 0. \quad (8)$$

From these two equations, A can be eliminated to find C and *vice versa*. The values of A and C are

$$A = \frac{1}{6Rb}\left[Ea(a - 3b) + \frac{Eg(b - a)^3}{a}\right]. \quad (9)$$

$$C = \frac{1}{6Rb}\left[\frac{Ea^3}{a - b} - Eg(4b^2 + ba + a^2)\right]. \quad (10)$$

By substituting the value of C in equation (4) and by placing y equal to a to obtain the maximum stress, the following equation is obtained:

$$Sga = \frac{-1}{6Rb}\left[\frac{Ea^2}{b-a} + Eg(4b^2 + ba + a^2)\right] + \frac{6Eg}{6R}a.$$

Collecting the terms in E and Eg,

$$Sga = \frac{-1}{6Rb}\left[\frac{Ea^2}{b-a} + Eg(-6ba + 4b^2 + ba + a^2)\right]$$

$$Sga = \frac{-1}{6Rb}\left[\frac{Ea^2}{b-a} + Eg(4b-a)(b-a)\right]. \quad (11)$$

Inasmuch as the thickness of the glaze is very small with respect to that of the body, the term in Eg does not amount to 1% of the total and can be neglected. Therefore, the equation becomes

$$Sga = \frac{-Ea^2}{6Rb\ (b-a)} \quad (12)$$

It may seem strange at first that the modulus of elasticity of the glaze does not enter into the equation for stress in the glaze; this, however, is just what *should be* expected. The bending of the beam is due to the differential thermal expansion of the body and the glaze. This bending is opposed by a layer of body of modulus of elasticity, E, and of thickness (a), and a layer of glaze of modulus of elasticity, Eg, and of thickness of $(b-a)$. Even though the two moduli are comparable with one another, the thickness of the glaze is so small compared with that of the body that the glaze layer does not contribute to the stress in the manner in which the body contributes to it. It can be easily seen from the exact equation for Sga that, if the thickness of the glaze $(b-a)$ was increased so that it was comparable with the thickness of the body, the term in Eg would become larger and the term in E would become smaller. Thus, the only reason that Eg does not come into the equation for stress in the glaze is that the thickness of the glaze is very small compared with the thickness of the body.

To find the equation for stress in the body, the value of A must be substituted into equation (1). By substituting this and by letting $y = a$, for maximum stress, the following equation is obtained:

$$Sa = \frac{1}{6Rb}\left[Ea(a-3b) + Eg\,\frac{(b-a)^2}{a}\right] + \frac{6Ea}{6R}. \quad (13)$$

Collecting the terms in E and Eg,

$$Sa = \frac{1}{6Rb}\left[E(a^2 + 3ab) + Eg\,\frac{(b-a)^2}{a}\right]. \quad (14)$$

On actual calculation, the term in Eg is much less than 1% of the term in E, because the thickness of the glaze enters into the equation as a cube term. Therefore the equation becomes

$$Sa = \frac{1}{6Rb}\left[E(a^2 + 3ab)\right]. \quad (15)$$

The term $(a^2 + 3ab)$ can be shown equal to $4ab$ within 1% for the experimental values used in this work. Therefore

$$Sa = \frac{4Eab}{6Rb} = \frac{2Ea}{3R}. \quad (16)$$

It should be noticed at this point that the values of glaze stress are negative and those of body stress are positive for the case of Fig. 3 (glaze in compression, body in tension). This criterion will be followed throughout the work. When the bar bends in the other direction, the radius of curvature, R, becomes negative and the stresses are reversed.

To make the equation of stress applicable to the results of this work, the radius of curvature, R, must be found in terms of the deflection of the beam, d. This can be determined from the well-known equation used in the beam theory as follows:

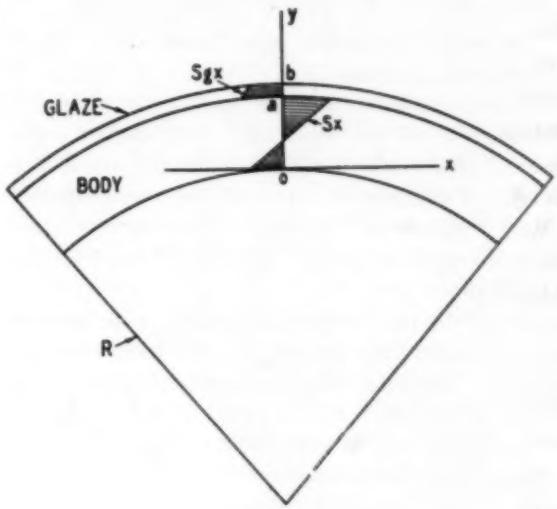


FIG. 3.

$$\frac{d^2v}{dx^2} = \frac{1}{R}. \quad (17)$$

x = distance from point of support.
v = deflection.

The first integration gives

$$\frac{dv}{dx} = \frac{x}{R} + C. \quad (18)$$

But, for a cantilever beam, $\frac{dv}{dx} = 0$ when $x = 0$; therefore $C = 0$.

The second integration gives

$$v = \frac{x^2}{2R} + C^1. \quad (19)$$

But $v = 0$ when $x = 0$; therefore $C^1 = 0$.

The equation then becomes

$$v = \frac{x^2}{2R}. \tag{20}$$

When $x = l$, let the deflection be d^1 (l = length of glazed bar).

$$\text{Therefore } d^1 = \frac{l^2}{2R} \text{ or } R = \frac{l^2}{2d^1}. \tag{21}$$

Now, the deflection, d, which was measured on the type of sample used in this thesis, is equal to $2d^1$. Therefore

$$R = \frac{l^2}{d}. \tag{22}$$

Where d = deflection as measured on tuning-fork sample.

Substituting (22) in (12) and (16), they become

$$Sa = \left(\frac{2Ea}{3l^2}\right) d. \tag{23}$$

$$Sga = \left(\frac{-Ea^3}{6bl^2\ (b - a)}\right) d. \tag{24}$$

The terms inside the parentheses are constant for any one specimen.

These equations of stress apply only when the specimen is allowed to bend. In an actual commercial piece, however, the ware is not allowed to bend. Equations of stress in the straight piece therefore must be derived. The latter should show a greater stress for the straight than for the curved piece.

When the bar is straightened out, the stresses will no longer vary with y, but will have constant values. The total force acting on an area of unit width of the glaze will be equal to the total force acting on an area of unit width of the body. Expressed mathematically, this is

$$Sa'a + S'ga\ (b - a) = 0. \tag{25}$$

The difference between the stress in the straight piece and in the curved piece of the body, divided by a like term for the glaze, will be equal to the ratio of their moduli of elasticity.

$$\text{Thus, } \frac{S'a - Sa}{S'ga - Sga} = \frac{E}{Eg}. \tag{26}$$

The "primes" denote the stresses in the straight piece.

When $S'a$ is eliminated from these two equations, the final result is

$$S'ga = \frac{Sga - \frac{Eg}{E} Sa}{1 + \frac{Eg}{E} \frac{b - a}{a}}. \tag{27}$$

This gives the stress in the straight case for the glaze as a function of the stress in the curved body and glaze.

It was found easier to determine the values of Sga and Sa as functions of d and then to substitute them in equation (27) rather than to solve it for $S'ga$ in terms of R, a, and b.

The values of a, b, and l, for each specimen, were determined with a pair of micrometer calipers and are given in Table I. The moduli of elasticity were measured carefully by making a cantilever beam from a bar of the body and making a curve of load *versus* deflection. This was done for each body and each maturing temperature, and the moduli of elasticity were calculated from the formula for a cantilever beam. The moduli of elasticity of the glazes were calculated from equations given by Hall.[2] Hall's factors agreed to within 10% of experimental results. If the equation for $S'ga$ is differentiated with respect to Eg, it is found that a 10% error in Eg will

TABLE I

PHYSICAL CONSTANTS OF VARIOUS COMBINATIONS OF BODIES AND GLAZES

Specimen	Body maturing temperature (°C)	a (mm.)	b (mm.)	l (mm.)	$E\left(\frac{\text{kg.}}{\text{mm.}^2}\right)$	$Eg\left(\frac{\text{kg.}}{\text{mm.}^2}\right)$
Body B and glaze B	1185	4.57	4.72	169	1870	6570
	1220	4.50	4.65	169	2210	6570
	1250	4.45	4.60	169	2480	6570
Body H and glaze H	1160	4.60	4.75	225	1800	8080
	1210	4.50	4.65	225	2205	8080
Body H and glaze B	1160	4.60	4.75	225	1800	6570
	1210	4.50	4.65	225	2205	6570

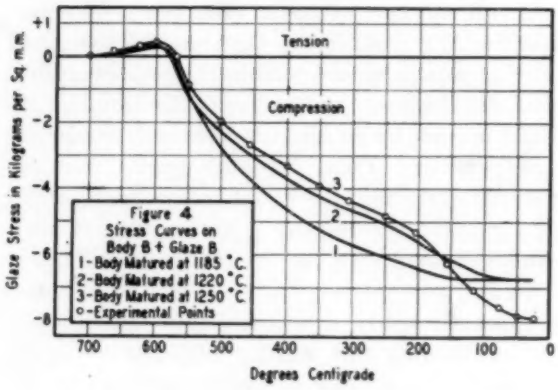


FIG. 4.

[2] F. P. Hall, "Influence of Chemical Composition on Physical Properties of Glazes," *Jour. Amer. Ceram. Soc.*, **13** [3] 182–99 (1930).

change $S'ga$ only by 1%; therefore, it seemed logical to use Hall's factors.

The values of stress for various combinations of bodies and glazes are shown in Table II.

TABLE II

VALUES OF STRESS IN VARIOUS COMBINATIONS OF BODIES AND GLAZES IN TERMS OF DEFLECTION OF ENDS OF SPECIMENS

Specimen	Body maturing temperature (°C)	Sga	Sa	$S'ga$
Body B and glaze B	1185	$-1.43d$	$+0.190d$	$-1.86d$
	1220	$-1.63d$	$+ .226d$	$-2.08d$
	1250	$-1.78d$	$+ .250d$	$-2.24d$
Body H and glaze H	1160	$-0.798d$	$+ .106d$	$-1.11d$
	1210	$-0.925d$	$+ .129d$	$-1.25d$
Body H and glaze B	1160	$-0.798d$	$+ .106d$	$-1.06d$
	1210	$-0.925d$	$+ .129d$	$-1.20d$

The stresses are all in kilograms per square millimeter, if d is measured in millimeters.

IV. Discussion of Stress Curves

The stress curves for various body and glaze compositions are shown in Figs. 4 to 8. They indicate how the stress in the glaze varies with decreasing temperature.

They all start at zero stress around 700°C, because above that temperature the glaze is fluid

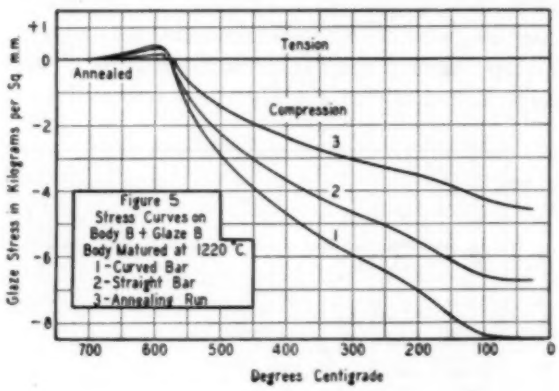


FIG. 5.

enough to prevent any stress development. From 700°C to 590°C, the curves show a small rise into tension. This rise is due to the fact that, in the above range of temperature, the contraction of the glaze (due to secondary expansion) is more rapid than that of the body. With slow cooling rates, this tension peak probably would be absent. Below 590°C, all the curves show a dip into compression which is slight in some cases and very deep in others.

The curves for body B and glaze B show that, for these combinations, the glaze is left in strong compression at room temperature. The latter result was to be expected because the glaze and

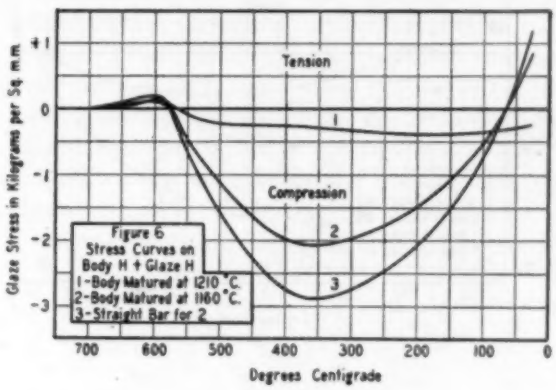


FIG. 6.

body had already given good service in commercial use. The experimental points are plotted on curve (3), Fig. 4, to indicate the consistency of the original data. All other curves are fitted to the experimental points in the same way.

The curves for body H and glaze H are shown on Fig. 6. The body, matured at 1210°C, does not deviate very far from the zero stress line at any temperature, while the underfired body (1160°C) shows a sharp dip into compression and then an equally rapid rise into tension. The glaze in the latter case crazed, while in the former it did not craze. In this case, a tension of 0.89 kilogram per square millimeter was enough to cause crazing.

The curves on body H and glaze B (Fig. 7) show a dip into compression and then a rise into tension. The curve for the body matured at 1210°C shows a smaller dip into compression and also a smaller rise into tension than the one matured at 1160°C. In both cases the glaze crazed, but in the latter, which showed the greater tension, the crazing took place to a more marked degree. In this case, a tension of 0.16 kilogram per square centimeter was enough to craze the glaze.

In Figs. 5, 6, and 8, the theoretical stress in a straight bar of the same dimensions is also plotted to show it in relation to the stress in the curved bar.

To determine the effect of annealing on stress development, annealing runs were made on two

of the specimens. These runs were made on specimens of body B, matured at 1220°C with glaze B; and also on body H, matured at 1160°C with glaze B. The specimens were annealed at

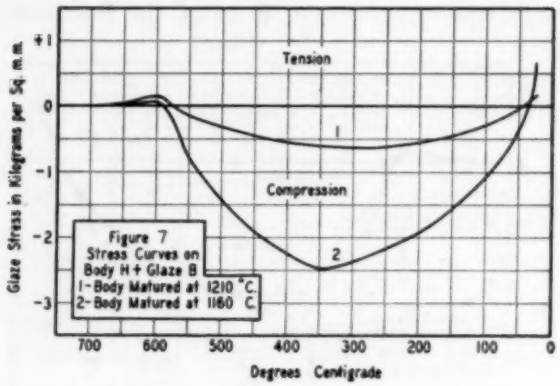


FIG. 7.

590°C for $1^1/_2$ hours and cooled, 10°C the first hour, 20°C the second hour, 30°C the third hour, and 40°C the fourth hour. The current was then shut off and the furnace was allowed to drop to room temperature.

The curves (Figs. 5 and 8) show that the stress in each specimen was moved toward tension. In the case of glaze B and body B, the glaze was left in less compression than it showed on the ordinary cooling run, and in the case of glaze B and body H it showed more tension. The latter showed pronounced crazing upon being removed from the furnace. It was hoped that annealing would decrease the tendency toward crazing but, for the glazes and bodies studied, the reverse effect was true. Additional work on annealing at other temperatures, however, is needed.

Benrubi[3] states that tension is always developed in the glaze above its transformation point. This fact is borne out by the glaze-stress curves (Figs. 4 to 8) obtained in this thesis. The tension in all cases is very small in relation to the rest of the curve and in every case is relieved around 590°C.

Benrubi says that the tension can be relieved by annealing the specimen slightly above the transformation point of the glaze. This fact is shown to be true from the annealing curve in Fig. 5, in which case the stress curve drops down to the zero stress line at the annealing temperature (590°C).

[3] J. H. Benrubi, "The Fit of Bodies and Glazes," *Verre Silicates Ind.*, **7** [6] 61–65; [7] 73–77; [8] 90–93 (1936); *Ceram. Abs.*, **15** [7] 211 (1936).

Benrubi's work brings out the interesting point that, if the piece is quenched rapidly from a temperature above the transformation point of the glaze, the glaze stresses are moved toward compression. This is due to the fact that the expansion curves for quenched glazes are lower than those for annealed glazes. A glaze showing tension on a slow cooling run might therefore show compression on a rapid quench. Actually, however, quick quenching often increases the crazing.

V. Change in Stress Due to Delayed Contraction and Autoclaving

The stress in the glazes did not reach a constant value as soon as the specimen dropped to room temperature. Instead, it required about a month or more for an equilibrium value to be attained. This change of stress is shown in Table III. In column (1), the stresses immediately upon cooling to room temperature are shown, and the stresses in the same specimens one month later are given in column (2). It is interesting to note that in each case the glaze moved toward tension; that is, the glazes in compresssion showed less compression after the lapse of a month and the glazes in tension showed more tension. In one case (body H, matured at 1210°C, and glaze B), the glaze actually changed from compression to tension. Upon first removing from the furnace, this piece showed no signs of crazing, but one month later an indistinct network of crazing was evident. The specimen of body H (matured at 1210°C) and glaze B had crazed slightly when removed from

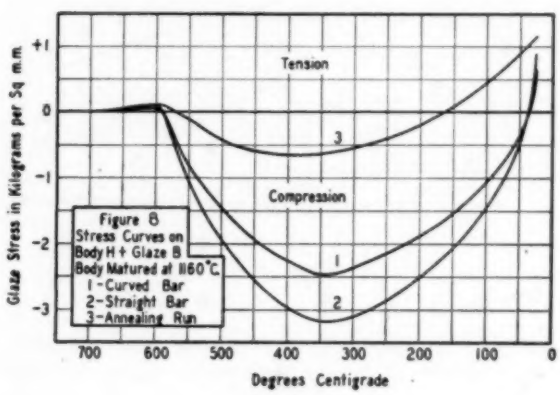


FIG. 8.

the furnace, but after a lapse of a month the effect had greatly increased. The specimens of body B and glaze B did not craze because they were in strong compression to start with.

This effect is known among ceramists as "delayed crazing." It is due to a property of glass termed "delayed contraction," or as it is called in Germany, the "thermische Nachwinkung." Mellor[4] describes this property very clearly. "A time factor is involved in the reversible cooling-contraction of glazes, since the return to the normal volume, at room temperatures, may take place so sluggishly that the last stages of the contraction may occupy weeks or even months. This time-lag produces what may be regarded as a *residual contraction* of the glaze after it has cooled down to room temperature."

The delayed contraction of the glazes thus explains why, in each case, the glaze moved in the direction of tension. It has the same effect as augmenting the coefficient of expansion of the glaze with respect to that of the body, which would move the glaze stress in the direction of tension. It is interesting to note that delayed contraction works against strong tension as well as with compression.

After all of the specimens had been given enough time to show the change of glaze stress due to delayed contraction, they were placed in an autoclave and treated with steam at 150 pounds per square inch for one hour. After the autoclaving treatment, the specimens were returned to the glaze testing furnace and their deflections were remeasured. The new glaze stress is shown in Table III, column (3).

As may be readily seen, most of the stresses were moved toward tension in a marked degree. It is interesting to note, however, that the specimens of body H, matured at 1160°C, and glaze B and glaze H showed less tension than before autoclaving. This is due to the fact that in both cases the crazing was so extreme that it relieved some of the original stress. In the cases of body B (matured at 1250° and 1220°C) and glaze B, the autoclaving reduced the compressive stress to a marked degree, but in the case of body B, matured at 1185°C, the stress was actually changed to tension. Thus, the former two do not show crazing, while the latter does. The reason for the greater change in stress of the low-fired body (1185°C) is that it had a greater porosity and was affected more by the steam of the autoclave.

As far as stress development in the glaze is concerned, an expansion of the body is equivalent to a contraction of the glaze. Thus, autoclaving removes the stress in the direction of tension for the same reason as the delayed contraction of the glaze. All of the combinations of bodies and glazes, except body B (matured at 1220°C) with glaze B, would not come up to the standard of good commercial ware, since they would craze if used under moist conditions. The two mentioned, however, would give good service even under conditions of extreme moisture, which checks with service results.

TABLE III

CHANGE OF GLAZE STRESS DUE TO DELAYED CONTRACTION AND AUTOCLAVING

Specimen	Maturing temp. of body (°C)	(1)	(2)	(3)
Glaze B and body B	1185	−6.70 (no crazing)	−5.37 (no crazing)	+0.59 (slightly crazed)
	1220	−6.70 "	−5.90 "	−1.51 (no crazing)
	1250	−7.89 "	−7.16 "	−2.10 "
Glaze H and body H	1160	+0.79 (slightly crazed)	+0.264 (very bad)	+2.32 (very bad)
	1210	−0.22 (no crazing)	+0.14 (indistinct network)	+1.25 "
Glaze B and body H	1160	+1.17 (very bad)	+1.73 (very bad)	+1.48 "
	1210	+0.31 (slightly crazed)	+0.83 (bad)	+1.74 "

(1) Glaze stress on removal from furnace (kg./mm.²).
(2) Glaze stress one month later (kg./mm.²).
(3) Glaze stress after autoclaving (kg./mm.²).
Positive values, tension.
Negative values, compression.

VI. Stress from Thermal-Expansion Curves

The curves for the thermal expansions of glaze B and glaze H are shown in Fig. 9. Both glazes are similar in shape, since both are of the whiteware type. Except for a small hump near 200°C, both curves have a practically constant slope up to a temperature of 570°C. This temperature is known as the transformation point of the glaze. Above it, the glaze begins to soften in a regular

[4] J. W. Mellor, "The Crazing and Peeling of Glazes," *Trans. Ceram. Soc.* [Eng.], **34** [1] 1–112 (1934); *Ceram. Abs.*, **14** [9] 233 (1935).

manner, and its expansion rate is approximately four times as great. Finally, as the temperature is increased, the glaze becomes so fluid that the end of the specimen bends and the curve reverses itself.

All of the curves for the bodies (Fig. 9) show three important features: (1) there is a practically constant slope, varying with the body, up to approximately 560°C; (2) there is a rapid increase

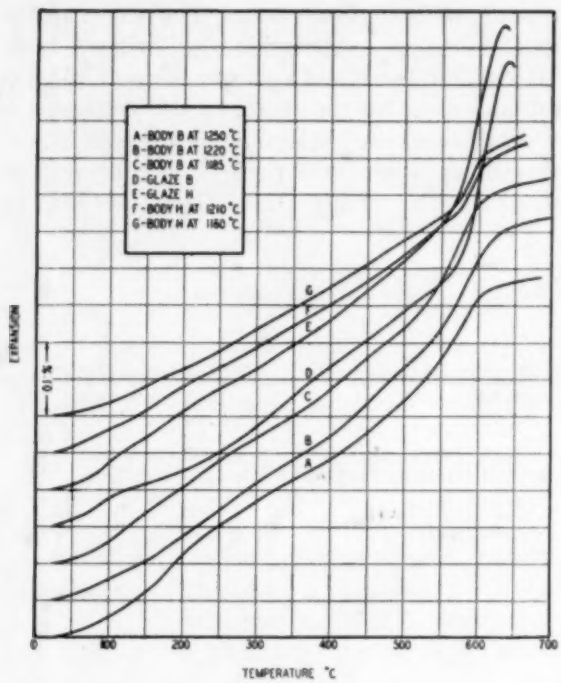


FIG. 9.

in slope above 560°C due to the transformation point of quartz; and (3) at about 610°C, the slope becomes less and reaches a value close to the original slope. The size of the transformation effect is influenced by the amount of quartz in the body and also by the maturing temperature. The bodies matured at higher temperatures show the effect much less because there is a greater glass formation at the expense of the quartz.

If the expansion of the body is greater than that of the glaze at the softening point of the latter, the final glaze stress will be compressive; if the reverse is true, the glaze stress will be tension. In order to use this rule, the softening point of the glaze must be defined. Because the viscosity of the glaze varies regularly above its transformation point, the softening point must be some arbitrarily defined value, agreeing with experimental results. It seemed best for the work of this thesis to define the softening point as that temperature at which the glaze-stress curve (Figs. 4 to 8) crossed the zero line, for at that point the length of the body must be equal to that of the glaze. Any stress finally developed below it is due to the difference between the expansion curves of the two components at this temperature. The magnitude and direction of the stress should be equal, qualitatively at least, to the magnitude and direction of the difference between the expansion curves.

Because body H shows less expansion than either of the glazes, the stress curves for this body should show the glaze in tension. This is borne out by the curves (Figs. 4 to 8). All of the stress curves for body B cross the zero line approximately at 590°C. At that temperature, the expansion of the body (for all maturing temperatures) is greater than that of the glaze (glaze B); therefore, all of the specimens of body B and glaze B should show compression. The curves (Figs. 4 and 5) show this to be true. Thus, the stress in the glaze can be predicted qualitatively from the expansion curves.

It is common commercial practice to predict the final glaze stress in a piece by using factors, such as are given by Hall,[2] to compute the coefficient of expansion of the glaze. From this value, the actual expansion of the glaze up to its softening point is obtained. Then the difference between the expansion of the glaze and that of the body at the softening point of the glaze is taken to be a measure of the final stress in the glaze. If it is positive, the glaze is in tension, and if it is negative, the glaze is in compression. Actual values of the glaze stress are seldom computed.

In order to test the correctness of the criterion that the stress in a glaze is proportional to the difference between the expansion curves of the glaze and the body, difference curves were plotted for the case of body B and glaze B (Fig. 10). If the stress is proportional to the difference between the expansion of the glaze and that of the body, these curves should show the same shape as the glaze-stress curves for the same body and glaze. The only similarity between them, however, is that they both show that the final glaze stress should be compressive. Thus, it is fairly evident that the glaze stress can be predicted qualitatively but not quantitatively from the difference curves. One of the big difficulties in deter-

mining glaze stress by this method is that the difference between the two curves is so small that a very small error in the determination of either curve will introduce considerable error into their difference. Even so, it is hardly probably that such a vast dissimilarity would be shown between the differences and the glaze-stress curves.

On the examination of the thin sections quenched at higher temperatures, there was evidence that the glaze was dissolving quartz from the body. Inasmuch as the rate of diffusion

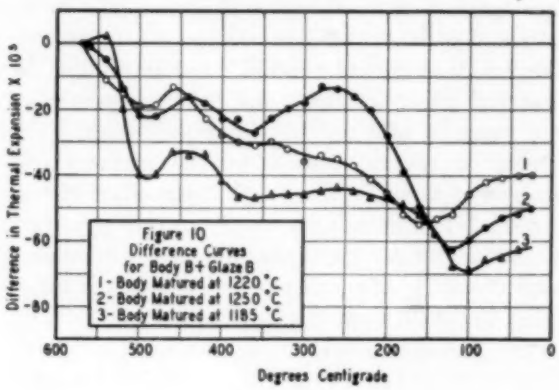


FIG. 10.

would be very low, owing to the viscosity of the glaze, it is reasonable to assume that a layer of glaze, rich in silica, is formed next to the body. This layer should have a pronounced effect on the glaze and should form a sort of transition layer. When the thermal expansion, measured for the pure glaze, is applied to such a structure, it is evident that discrepancies will show up in the calculation of stress from the expansion curves. For that reason, it is doubtful that stress in the glaze can be calculated from expansion curves with any degree of precision, although the direction of the stress can be predicted with fair certainty.

VII. Conclusions

(1) Glazes in high compression (8 to 10 kg./mm.^{2}) show no signs of failure on removal from the kiln or even after autoclaving, but those even in the slightest tension show a tendency to craze.

(2) Delayed crazing is caused by a delayed contraction of the glaze. It often takes weeks for this contraction to reach an equilibrium. The change of glaze stress caused by delayed contraction is always in the direction of tension.

(3) Autoclaving always moves the glaze stress in the direction of tension because moisture causes the body to expand. In general, a glaze must be in high compression to withstand the autoclave test. Bodies with a high porosity show a greater tendency to craze on autoclaving, inasmuch as they are affected to a greater extent by the moisture of the autoclave.

(4) In general, the low-fired bodies showed a greater tendency toward tension in the glaze and, consequently, crazing. In the case of body B and glaze B (the correctly matured body and the overfired body) both showed high resistance to crazing, thus checking well with service results.

(5) The difference between the thermal-expansion curves of the glaze and the body is only a qualitative indicator of glaze stress. It is, however, a valuable auxiliary to the deflection method of stress determination.

Acknowledgment

The author wishes to express his sincere appreciation to F. H. Norton for his helpful guidance on the work of this thesis. His help in the preparation of the article for publication has been invaluable. He also wishes to thank R. W. Vose of the Mechanical Engineering Department for his help in the deviation of the stress equations.

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THE EFFECT OF DIFFERENT BODIES ON SOME WETTING AND FLOW CHARACTERISTICS OF GLAZES*

By C. Major Lampman

Abstract

Variations in the fluid properties of glazes produced by different bodies were studied, and several methods for testing the wetting ability of the glazes were compared. An angle-of-contact method was found best for measuring the ability of glazes to wet bodies. It was found that different bodies had varying effects on the fluid properties of a glaze. The maturing temperatures of a glaze are not fixed for a given glaze but may vary as much as four cones on different bodies, if wetting ability is considered in determining this temperature.

I. Introduction

In fitting glazes to bodies, their adherence and ability to wet bodies at furnace temperatures are too frequently overlooked. Glazes that crawl or fail to adhere to certain bodies may cover other bodies uniformly, often filling surface cracks and cavities, a fact which led to the belief that reactions between bodies and glazes play an important rôle in the ability of glazes to wet and adhere to bodies at furnace temperatures. An investigation was conducted to test this assumption and the results strongly confirm it.

The ability of glazes to wet bodies was studied by four methods. The angle-of-contact method is similar to that employed by Barrett and Taylor[1] for slags on iron. Instead of making the measurements in a furnace, however, separate specimens were fired at different temperatures, and measurements were made on the fused buttons after removing them from the kiln.

The surface tension of liquids can be determined from accurate measurements of the dimensions of these sessile drops,[2] and this method has been used to determine the surface tension of viscous liquids at high temperatures.[3] Although no attempt was made to ascertain the actual surface tensions or viscosities in this work, the measurement of the angle of contact may be considered an empirical method for determining the practical effects of these and other properties of the glaze as affected by different bodies. The effects of several bodies on the inclined and horizontal flow of glazes and the radii of curvatures of fused buttons were also determined. These methods, furthermore, were compared with the angle-of-contact test as a means of measuring the ability of glazes to wet bodies.

The purpose of this work, therefore, was twofold, *viz.*, (1) to study the effect of different bodies on the fluid properties of some glazes and (2) to test the utility of four methods for measuring the wetting ability of glazes on different bodies.

II. Materials and Methods

The compositions and formulas of the glazes are given in Tables I, II, and III. The bodies used were Monmouth (Illinois) stoneware clay, Hudson River clay, Syracuse clay, Binghamton shale, and a mixture of one part of surface clay and six parts of shale from the vicinity of Buffalo.

The flow of glazes on inclined and flat surfaces was studied by methods described in a previous report.[4] In studying the flow of glazes on horizontal surfaces, 1-inch spheres, weighing 16 grams, were molded from the raw glazes. These were set in the centers of disks made of the unfired clay bodies. The flow was measured by noting the diameters of the fused buttons after firing to different temperatures in about fifteen hours. After they were removed from the kiln, the fired specimens were cut in two pieces with a silicon-carbide saw. The vertical sections through the glaze buttons and the clay disks were projected on a screen

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (White Wares Division). Received December 6, 1937.

[1] E. P. Barrett and J. A. Taylor, "New Method for Studying Flow Characteristics of Glasses and Slags at Elevated Temperatures," *Jour. Amer. Ceram. Soc.*, **19** [2] 39–44 (1936); see also comments by J. H. D. Heine and by the authors, *ibid.*, **21** [6] 213–15 (1938).

[2] (*a*) T. W. Richard and S. Boyer, "Further Studies Concerning Gallium," *Jour. Amer. Chem. Soc.*, **43** [2] 274–93 (1921).

(*b*) N. E. Dorsey, "New Equation for Determination of Surface Tension from the Form of a Sessile Drop or Bubble," *Jour. Wash. Acad. Sci.*, **18** [19] 505–509 (1928).

[3] B. S. Ellefson and N. W. Taylor, "Surface Properties of Fused Salts and Glasses: I, Sessile Drop Method for Determining Surface Tension and Density of Viscous Liquids at High Temperatures," *Jour. Amer. Ceram. Soc.*, **21** [6] 193–205 (1938).

[4] C. M. Lampman, "Flow of Glazes on Flat and Inclined Surfaces," *Bull. Amer. Ceram. Soc.*, **17** [1] 12–16 (1938).

with a delineascope which magnified them about ten times. The enlarged image of the button showing the contact of glaze and body was then traced on paper. From this tracing, the angle of contact was determined by drawing a tangent to the glaze outline at the point of contact with the intersection points of perpendiculars to the tangents as shown.

III. Results

The inclined flows of seven glazes on Monmouth and Hudson River clays when fired to cone 02 are given in Fig. 2. Most of the glazes flowed more freely on the Hudson River clay than they did on Monmouth stoneware clay, although all specimens were fired to the same temperature.

TABLE I

COMPOSITIONS OF GLAZES

	2B	2D	2E	2F	2G	2H	2M	2O	2Q	2R
Potash feldspar						34.7			32.4	
Soda-potash feldspar										31.4
Whiting						3.1				2.8
Zinc oxide						2.4			6.6	2.2
Magnesium carbonate						2.6				2.3
Barium carbonate									16.0	
White lead						39.4				
Colemanite									11.2	
Georgia kaolin	7.3	7.5	8.3	5.0	7.0	2.4	5.7	8.3		
English ball clay										
Flint						10.8			27.8	2.2
Tin oxide	6.4	6.5		4.3	7.7	4.6			6.2	4.1
Opax								8.3		
Frit 2B	86.3									
Frit 2D		86.0								
Frit 2E			91.7							
Frit 2F				90.7						
Frit 2G					85.3					
Frit 4							94.3			
Frit 6								83.3		
Lead bisilicate frit										55.1

TABLE II

CHEMICAL COMPOSITION OF FRITS

Frit No.	NaKO	CaO	BaO	SrO	ZnO	PbO	B_2O_3	Al_2O_3	SiO_2	ZrO_2
2B	4.78	5.6				27.30	10.72	3.12	42.80	
2D	12.10		24.40				14.85	3.30	45.40	
2E	13.45			24.30			12.45	3.57	46.20	
2F	14.80						15.67	8.58	30.40	
2G	24.96	4.90					10.99	11.30	45.20	
4	3.68	4.41				30.46	12.60	3.41	42.82	2.30
6	10.00		20.00		20.00		20.00		20.00	
Lead bisilicate frit						65.20		2.40	32.40	

TABLE III

EMPIRICAL MOLECULAR FORMULAS OF THE GLAZES

	RO + R_2O = 1.00								R_2O_3	RO_2 + B_2O_3			
	K_2O	Na_2O	CaO	MgO	BaO	SrO	ZnO	PbO	Al_2O_3	SiO_2	B_2O_3	SnO_2	ZrO_2
2B	0.089	0.135	0.350					0.426	0.139	2.510	0.534	0.049	
2D	.210	.246			0.542				.128	0.628	.555	.050	
2E	.212	.140				0.648			.096	1.570	.350	.170	
2F	.396	.604							.446	2.590		.030	
2G	.318	.475	.211						.292	1.830	.370	.060	
2H	.157	.035	.105	0.101			0.098	.505	.241	1.900		.100	
2M	.138	.210						.652	.260	5.056	1.280		0.125
2O	.150	.150			.243		.457		.039	0.925	0.531		.082
2Q	.147	.035	.248		.285		.285		.210	2.870	.252	.140	
2R	.054	.070	.176	0.090			.087	.522	.223	2.250		.088	

The horizontal flow of the glazes on the bodies at different temperatures is shown in Figs. 3, 4, 5, and 6. It is evident that the flow of the same glaze often varied widely on different bodies.

The angle-of-contact measurements are given in Table IV and are shown in Figs. 7, 8, 9, and 10 on different bodies and at varying temperatures. The radius-of-curvature data for two of the glazes are given in Tables V and VI and in Figs. 11 and 12.

IV. Discussion of Results

(1) Inclined Flow

In most cases the inclined flow was greater on the fusible Hudson River clay than on the more refractory Monmouth stoneware clay (see Fig. 2). This flow, however, was practically the same on both clays for glazes 2F and 2G. The greater fluidity of most glazes on one body than another may originate from reactions between body and glaze. It is conceivable that a glaze will dissolve certain body ingredients in varying amounts depending upon the composition of the body and glaze. It is also possible that the body will absorb certain phases from the glaze. The dissolved ingredients in the glaze or the removal of certain portions of the glaze by the body may alter the composition of the glazes sufficiently to affect their fluid properties. The fineness of grain and po-

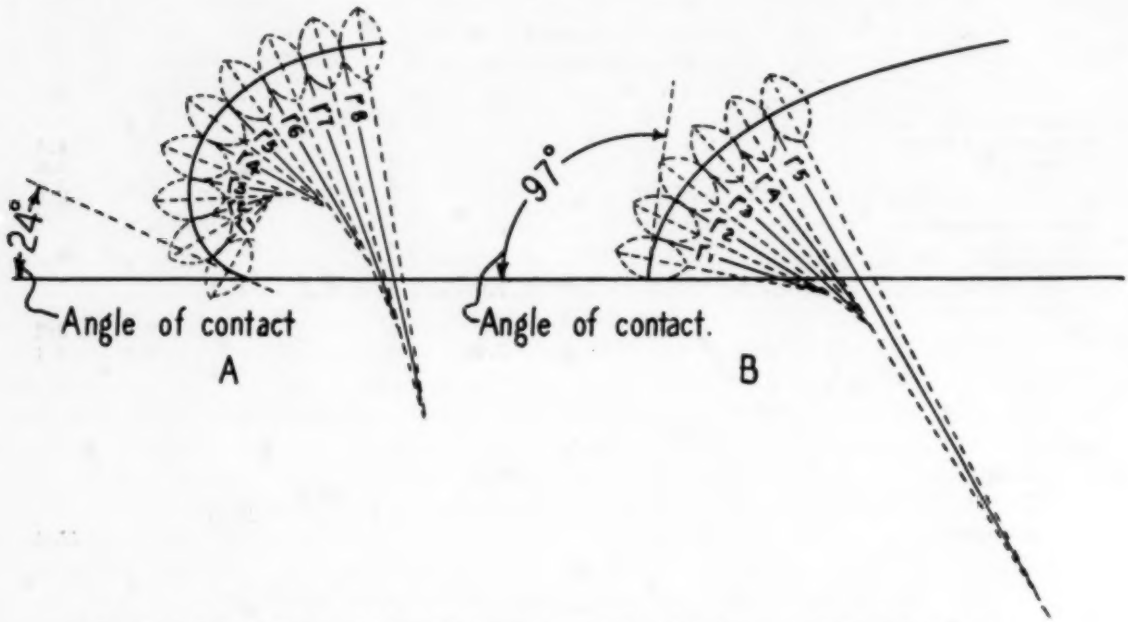

FIG. 1.—Method of determining radii of curvatures and angles of contact of fused glaze buttons.

TABLE IV

ANGLES OF CONTACT OF DIFFERENT GLAZE BUTTONS ON CLAY BODIES WHEN FIRED TO DIFFERENT TEMPERATURES

Angle of contact (in degrees)

	2B				2H		2Q		2R
	014	010	07	03	07	03	07	03	010
Monmouth (Ill.) clay	33.4	41.0	149.0	164.0	75.5	144.0	32.5	55.3	99.5
Syracuse clay	30.0	108.0	162.5	160.0	75.0	151.0	49.8	89.5	
Hudson River clay	42.0	57.0	143.5	154.0	75.5	125.0	26.7	73.5	76.0
Binghamton shale	34.3	50.3	137.2	158.0	44.7	70.0	23.3	49.0	65.5
Buffalo clay and shale mix	35.8	61.6	145.0	159.5	63.7	77.0	20.0	15.7	75.5

TABLE V

RADII OF CURVATURES OF GLAZE 2B BUTTONS WHEN FIRED ON FIVE DIFFERENT CLAY BODIES TO CONE 010

Distance along glaze button from point of contact (in.)	0.008	0.0704	0.205	0.267
	Radii of curvature (in.)			
Monmouth clay	0.0938	0.1079	0.1797	0.3117
Syracuse clay	.1532	.1937	.3984	.3008
Hudson River clay	.0679	.1055	.1715	.4977
Binghamton shale	.1109	.1180	.1876	.2986
Buffalo clay and shale mix	.0945	.1327	.1727	.3400

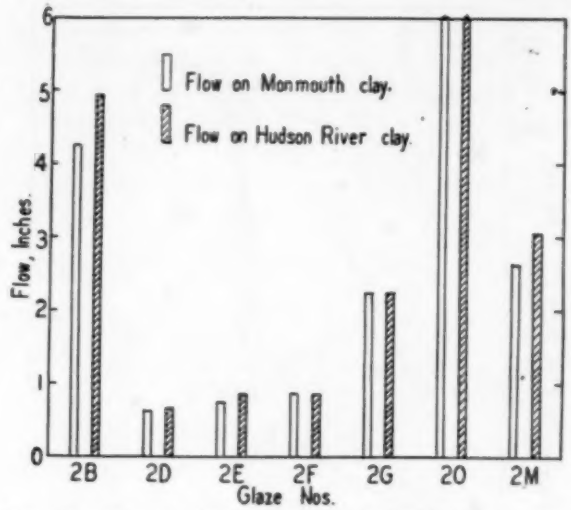

FIG. 2.—Flow of glazes in trough inclined 45° at cone 010.

rosity of the body would probably also influence the extent of these reactions.

(2) Horizontal Flow

The horizontal flow of individual glazes varied considerably on the five different clays (see Figs. 4, 5, and 6). With each glaze, it was greatest on Syracuse clay, while it was relatively small on Binghamton, Buffalo, and Monmouth clays. It is probable that the reactions between glazes and bodies produced these differences.

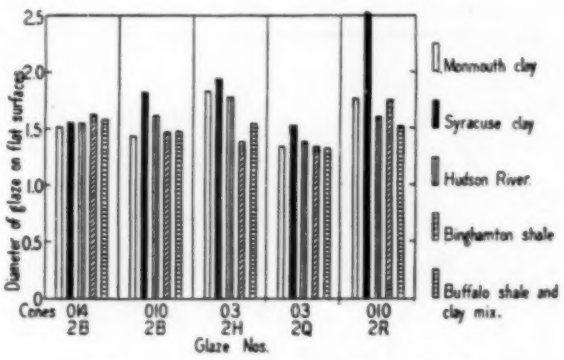

FIG. 3.—Flow of glazes on different clays.

TABLE VI

RADII OF CURVATURES OF GLAZE 2Q BUTTONS WHEN FIRED ON FIVE DIFFERENT CLAY BODIES TO CONE 030

	Distance along glaze button from point of contact (in.)				
	0.0246	0.0575	0.0900	0.1320	0.1970
	Radii of curvature (in.)				
Monmouth (Ill.) clay	0.1861	0.1547	0.2492	0.653	1.241
Syracuse clay	.1607	.1890	.2652		2.113
Hudson River clay	.1352	.1648	.2837		2.1925
Binghamton shale	.1361	.1548	.1940	.308	1.507
Buffalo clay and shale mix	.1321	.0946	.1602	.447	1.313

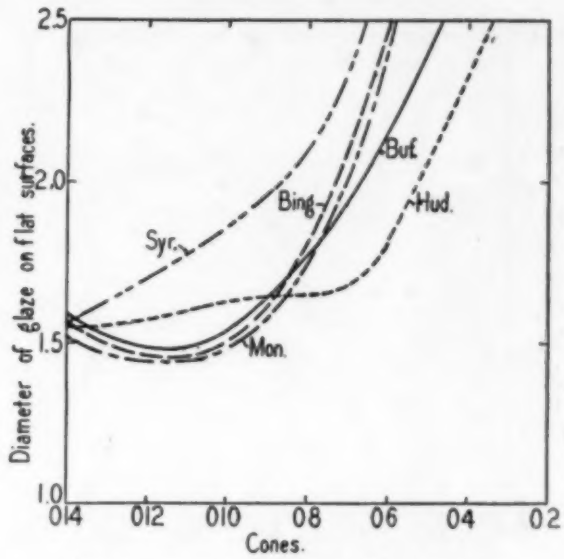

FIG. 4.—Flow of glaze 2B on different clays.

(3) Angle of Contact

Angle-of-contact measurements for glaze 2H are shown in Fig. 7. When the angle of contact is less than 90°, the sum of the gas-liquid and solid-liquid interfacial tensions is greater than the gas-solid interfacial tension. In this case, the liquid will assume a lenticular shape and will not

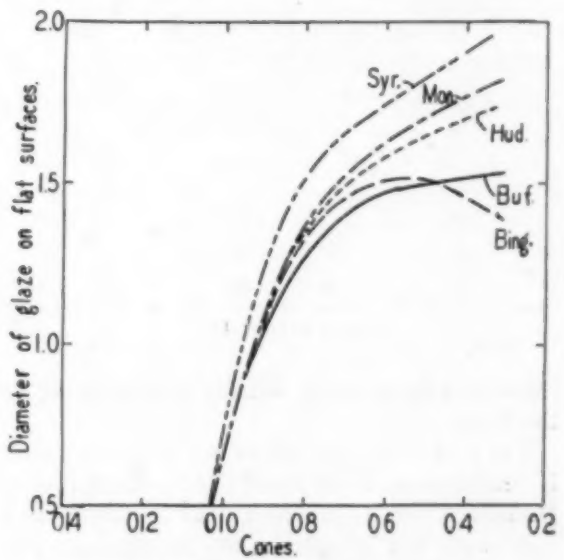

FIG. 5.—Flow of glaze 2H on different clays.

wet the surface (see Fig. 1*A*). On the other hand, if the angle of contact is greater than 90°, the gas-solid interfacial tension is greater than the other two interfacial tensions combined. The resultant

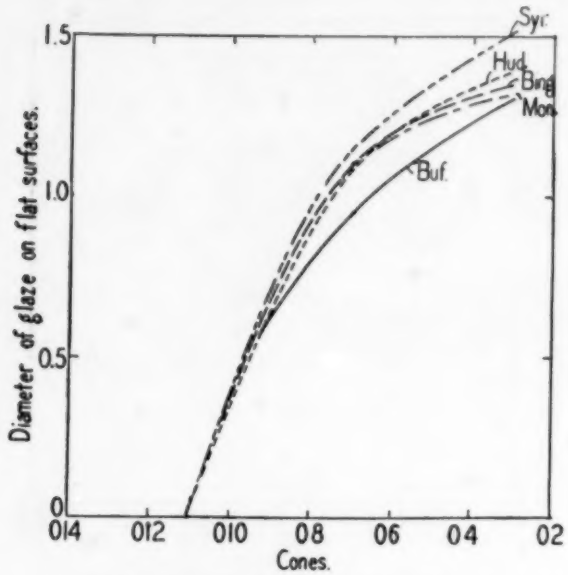

FIG. 6.—Flow of glaze 2Q on different clays.

of the forces, therefore, acts with gravity and the glaze spreads out and wets the surface (see Fig. 1*B*). It was assumed in this work that the angle of contact should be at least 90° before it can be

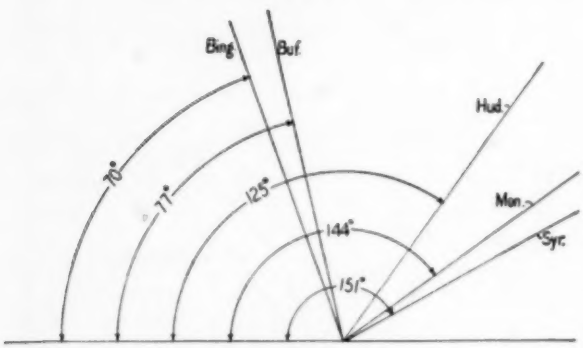

FIG. 7.—Angles of contact of glaze 2H on different clay bodies at cone 03.

considered as properly wetting and adhering to the body.

The ability of glaze 2H to wet different bodies is clearly shown in the figure. At cone 03, it wets Hudson River, Monmouth, and Syracuse clays very well, but it fails on the Binghamton and Buffalo clays.

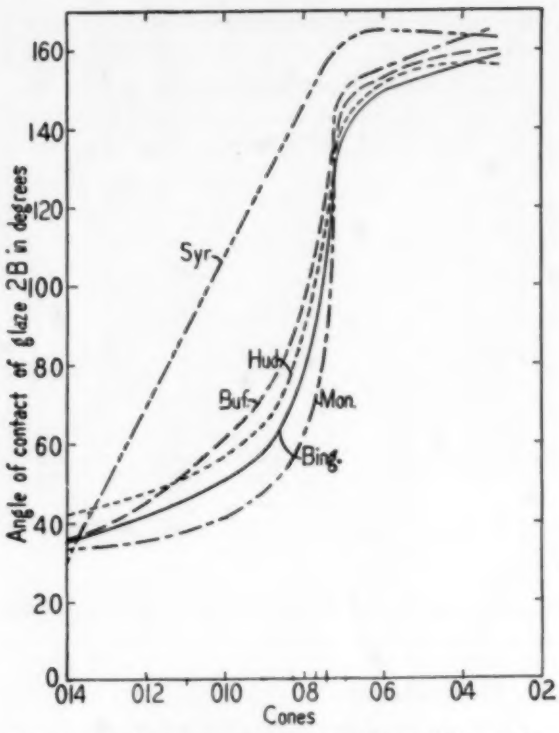

FIG. 8.—Angles of contact of glaze 2B on different clay bodies.

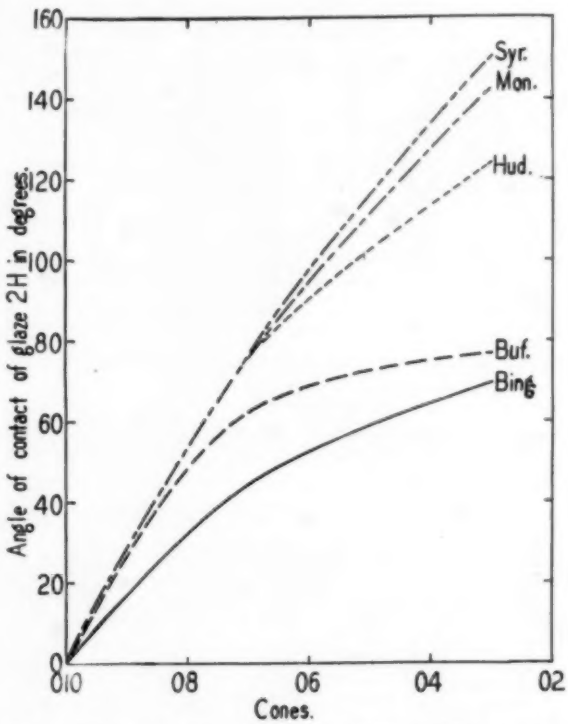

FIG. 9.—Angles of contact of glaze 2H on different clay bodies.

In Fig. 8, it can be seen that increasing the firing temperatures improves the ability of 2B to wet a clay; 2B, which is a lead-borax glaze, does not adhere properly to any of the clays until cone 011 is reached when the angle of contact becomes

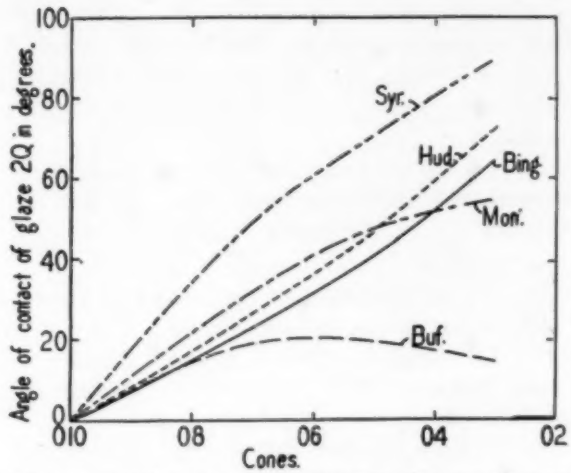

FIG. 10.—Angles of contact of glaze 2Q on different clay bodies.

90° on Syracuse clay. It does not wet the Buffalo clay properly until cone $08^1/_4$ is reached, while cone $07^1/_2$ is required for Monmouth clay.

It has been generally assumed in the past that the maturing temperature of a glaze is a constant, depending upon its composition, and that it is

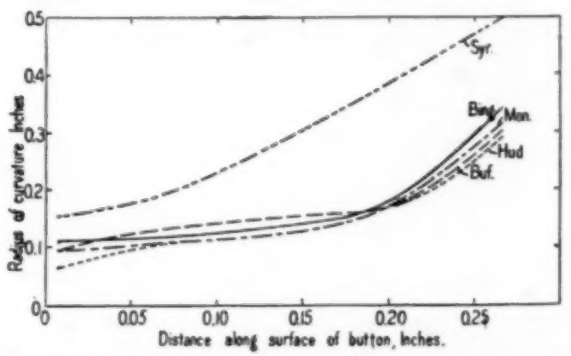

FIG. 11.—Radii of curvature of glaze 2B on different clay bodies at cone 010.

independent of the body on which it is applied. That this assumption is subject to limitations is evident from these results. Assuming that the glaze should correctly wet the body before it can be considered matured, the maturing temperature of 2B varies $3^1/_2$ cones, depending upon what body is used.

With glaze 2H, which is a raw lead glaze, the angle of contact becomes 90° for Syracuse, Monmouth, and Hudson River clays at cones 06 to $05^1/_4$, while it is less than 90° and fails to wet Buffalo and Binghamton clays at cone 03 (see Fig. 9). Because the Binghamton clay is a shale and the Buffalo clay is composed largely of shale, it is possible that shales are more difficult to wet than clays, owing to their denser structure.

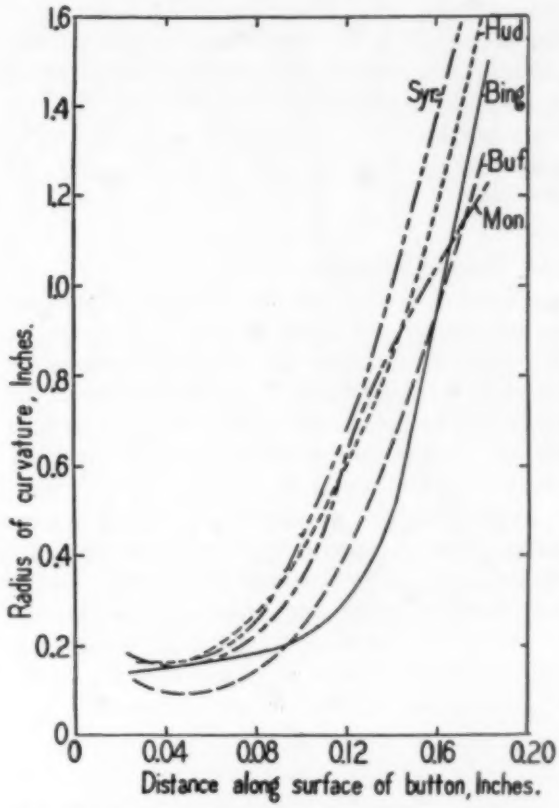

FIG. 12.—Radii of curvature of glaze 2Q on different clay bodies at cone 03.

Glaze 2Q wets Syracuse clay at cone 03 but fails to wet the other clays at this temperature. When this glaze is sprayed on tile and fired, it has the appearance of a fully matured glaze on all clays.

In comparing the horizontal flow of glaze 2Q with that of 2H (see Figs. 5 and 6), 2Q appears to be more fluid than 2H on Buffalo and Binghamton clays. Glaze 2H, however, wets these two clays better than 2Q when judged by the angle-of-contact data (Figs. 9 and 10). Both horizontal flow and angle-of-contact tests, however, indicate that 2B is more fluid than 2Q and 2H.

The angle-of-contact measurements give considerable data on the adherence and ability of glazes to wet bodies which the sprayed trials and flow tests fail to show. It is also evident that the maturing temperature of a glaze is not a constant but may vary as much as four cones on different bodies. This test is also promising as a means of measuring the effects of body and glaze reactions on the fluid properties of glazes.

It must be borne in mind that other properties than wetting must be considered in determining the proper maturing temperature of glazes. For example, if a glaze must be fired to a temperature at which it blisters before it can be made to wet a body properly, it evidently is not suitable for the body and its composition must be changed to fit the body.

(4) Radii of Curvatures

Similar data were obtained in radii-of-curvature measurements (see Tables V and VI and Figs. 11 and 12). In this case, glazes whose buttons develop the largest radii of curvatures near the body may be considered to have the best wetting ability. These data again indicate that Syracuse clay is most easily wetted.

Angle-of-contact measurements, however, permit a closer comparison than radii-of-curvature data and can be determined much easier. Of the four methods studied to determine their utility for measuring the ability of glazes to wet and adhere to ceramic bodies, it appears that the angle-of-contact test is by far the most satisfactory.

V. Summary

The effect of reactions between bodies and glazes on some of their fluid properties was studied. Four methods for measuring the wetting abilities of glazes at furnace temperatures were compared.

(1) Glazes flowed varying amounts on different clays in most cases, both in the inclined and horizontal flow tests. It is probable that the differences resulted from reactions between glazes and bodies.

(2) The radii of curvature of the glazes were different for the same glaze when applied on different bodies, the largest radii indicating high fluidity and wetting ability.

(3) The angle-of-contact measurements varied for the same glaze on different bodies.

(4) The angle-of-contact method permits a closer comparison of the glazes than is possible with the other three methods studied.

(5) If it is assumed that a glaze should correctly wet a body before it is considered matured, then this temperature may vary as much as four cones for the same glaze on different bodies.

(6) The angle-of-contact method is suggested as a means of measuring the ability of a glaze to wet and adhere to bodies. It shows differences between glazes not perceptible either in sprayed trial pieces or flow tests.

Acknowledgment

The author wishes to acknowledge the help of H. G. Schurecht, under whose direction this work was done, and also of M. E. Holmes for helpful suggestions.

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FOURIER ANALYSIS OF X-RAY PATTERNS OF SODA-SILICA GLASS*

By B. E. Warren and J. Biscoe†

Abstract

X-ray diffraction patterns were obtained for five compositions of soda-silica glass. The patterns were made in an evacuated camera, using MoKα radiation monochromated by reflection from rock salt. The patterns show a perfectly continuous change in appearance with increasing soda content. From a Fourier analysis of the X-ray scattering curves, radial distribution curves for the five glasses were obtained. The distribution curves uniquely establish several important points. Each silicon atom is surrounded by 4 oxygens at a distance of about 1.62A and each sodium by about 6 oxygens at 2.35A. The existence in the glass of simple discrete molecules, such as SiO_2, Na_2O, $Na_2Si_2O_5$, and Na_2SiO_3, is uniquely ruled out by the distribution curves.

The X-ray results lead to the following picture of soda-silica glass. Each silicon is tetrahedrally surrounded by 4 oxygens at a distance of about 1.62A. Part of the oxygens are bonded to 2 silicons and part only to 1 silicon. The sodium ions Na^+ are arranged in various holes in the silicon-oxygen network, being surrounded on the average by about 6 oxygens at a distance 2.35A. Although this is a definite scheme of structure, it does not repeat identically at regular intervals, and the material, therefore, is noncrystalline.

I. Introduction

By a Fourier analysis of the experimental X-ray scattering curve of a glass, a radial distribution curve is directly obtained. The importance of the method of Fourier analysis is found in the fact that it yields a radial distribution curve without any *a priori* assumptions having been made as to the structure of the glass. From the distribution curve, it is possible to make certain deductions as to number of neighboring atoms about any one atom and the distances at which these neighboring atoms are to be found. The amount of information about the structure of the glass which can be uniquely deduced from the radial distribution curve will depend upon the complexity of the glass.

The theory of the generalized Fourier method leads to the following expression for the weighted radial distribution:

$$\Sigma K_m 4\pi r^2 \rho_m = \Sigma K_m 4\pi r^2 \rho_0 + \frac{2r}{\pi}\int_0^\infty si(s) \sin rs\, ds. \quad (1)$$

Σ = summation over assumed unit of composition.
r = distance from any atom.
K_m = effective number of electrons in atom, m, and is defined by the relation, $K_m = f_m/f_e$ (it is not strictly constant so that an average value must be used).
$4\pi r^2 \rho_m dr$ = number of atoms, each multiplied by its effective number of electrons, between distances r and $r + dr$ from the atom, m.
ρ_0 = average number of electrons per unit volume.
$s = \frac{4\pi \sin\theta}{\lambda}$
$i(s) = \frac{I_{eu} - \Sigma f_m^2}{f_e^2}$
I_{eu} = experimental intensity of unmodified scattering in electron units per unit of composition.
f_m = atomic scattering factor for atom m.
$f_e = \frac{\Sigma f_m}{\Sigma Z_m}$ = average f per electron.
Z_m = atomic number of atom m.

The curve, $si(s)$, is obtained from the experimental X-ray scattering curve, and the integration involved in equation (1) is carried out with a harmonic analyzer for a number of values of r. The resulting values of $\Sigma K_m 4\pi r^2 \rho_m$ plotted against r give the radial distribution curve.

Up to now, the Fourier method has been applied only to two simple glasses,[1] SiO_2 and B_2O_3. In each case, the distribution curve gave directly the scheme of coördination; for example, in SiO_2 each silicon is tetrahedrally surrounded by 4 oxygens, and each oxygen is bonded between 2 silicons, the silicon-oxygen distance being about 1.62A.

In the present investigation, the Fourier method is applied to a series of soda-silica glasses. In a previous X-ray study of soda-silica glass,[2] the analysis was made by the cut-and-try method. A plausible structure for the glass was assumed and calculated X-ray scattering curves were compared with the experimental curves. The results of the present study are in essential agreement with the

* Part of a paper entitled, "Critical Summary of the Results of X-Ray Studies of Glass," presented at the Autumn Meeting, Glass Division, State College, Pa., September 10, 1937. Received January 8, 1938.

† Glass Research Fellow. (This paper is the second report of work done through a fellowship sponsored by eight American glass manufacturers.)

[1] B. E. Warren, H. Krutter, and O. Morningstar, "Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3," *Jour. Amer. Ceram. Soc.*, **19** [7] 202–206 (1936).

[2] B. E. Warren and A. D. Loring, "X-Ray Diffraction Study of the Structure of Soda-Silica Glass," *ibid.*, **18** [9] 269–76 (1935).

previous work. In the present study, however, no assumptions as to structure are involved, and whatever information is derived comes directly and uniquely from the X-ray data.

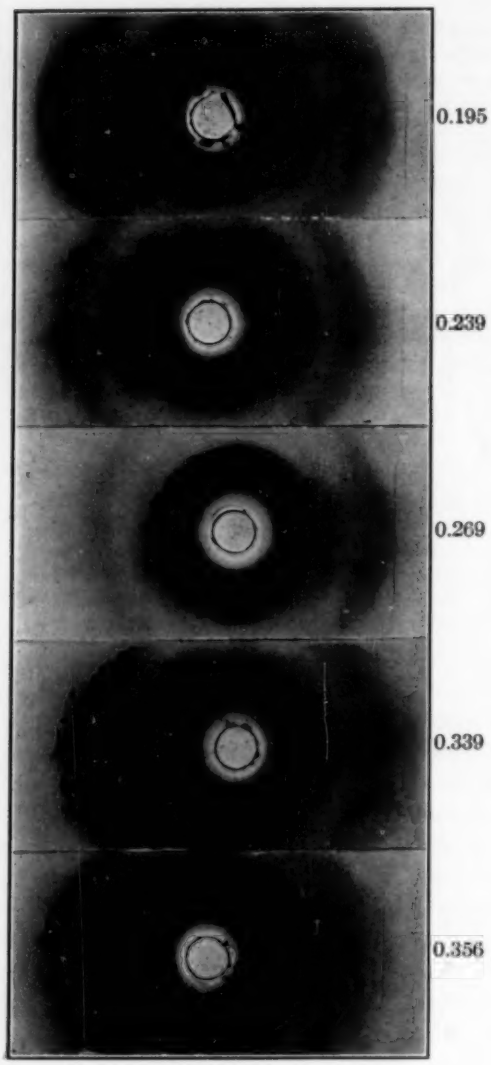

FIG. 1.—X-ray diffraction patterns of soda-silica glass; side numbers indicate weight percent Na_2O.

II. Glass Samples

X-ray studies were made on the five soda-silica compositions listed in Table I.

A small amount of impurity in samples (1) and (2) was handled by lumping together Al_2O_3 and Fe_2O_3 with SiO_2, and CaO with Na_2O. Samples (3) and (4) were material supplied by G. W. Morey for a previous X-ray study of soda-silica glass. Sample (5) was prepared from SiO_2 and Na_2CO_3, melted in a platinum crucible, and the final glass was analyzed for composition.

The diffraction sample in each case was a rod about 1 millimeter in diameter. These were prepared by drawing out a piece of the glass. To guard against action by water-vapor, the samples were freshly prepared just before using and were put immediately into the diffraction camera which was kept evacuated. The surface of the sample was quite clear at the end of a run, so that no appreciable surface alteration could have taken place. Using MoKα radiation (λ = 0.710A), the absorption in a 1-millimeter sample is very small. The whole volume of the sample is effective in scattering, and therefore the effect of a thin layer of altered material on the surface would be negligible.

TABLE I

COMPOSITION OF SODA-SILICA SAMPLES

Sample No.	Weight composition		Molecular composition	
	Na_2O	SiO_2	Na_2O	SiO_2
(1)*	0.195	0.805	0.190	0.810
(2)*	.239	.761	.233	.767
(3)	.269	.731	.263	.737
(4)	.339	.661	.332	.668
(5)	.356	.644	.346	.654

* Samples (1) and (2) were supplied by the Philadelphia Quartz Company. The authors are indebted to D. B. Curll, Jr., for making these samples available.

III. X-Ray Technique

The X-ray diffraction patterns were made with the same experimental technique that was used in the previous studies on SiO_2 and B_2O_3.[1] The cylindrical camera was of a radius 4.40 centimeters and was evacuated during the exposure to eliminate air scattering. The radiation was MoKα (λ = 0.710A) and was monochromated by reflection from a rock salt crystal. Exposures were of the order 10 to 20 hours.

Reproductions of the five diffraction patterns are shown in Fig. 1. These patterns differ from those obtained by Warren and Loring[2] in that they extend out to large values of $\frac{\sin\theta}{\lambda}$. This is due to the use of a cylindrical sample which allows the registering of radiation scattered at all angles up to 180°. In the previous study, the diffraction pattern was obtained by transmission through a thin slip, and because the absorption by the slip increases rapidly with the angle of scattering, it was possible to get only the first two

peaks of the pattern. Using MoKα radiation, the pattern is condensed to smaller angles, and there is no chance of losing outer peaks, which with CuKα radiation might come beyond 180°.

The first two peaks of Fig. 1 correspond to the two peaks recorded in the previous study. They show exactly the same variation with composition. With increasing soda content, the intensity of the first peak diminishes and the second peak increases.

IV. Fourier Analysis

Microphotometer records of the films were changed to intensity curves in the usual way. For each composition, at least two diffraction patterns were made. Using both sides of the microphotometer record, four sets of values for the intensity curve were available; the final curve was the average of these four sets, and in all cases there was good agreement among these sets.

The effect of absorption in the sample for MoKα radiation was so small that no correction was made. The polarization correction was made by dividing all curves by the polarization factor.

$$PF = \frac{1 + \cos^2 2\theta_0 \cos^2 2\theta}{2}.$$

θ_0 = glancing angle for reflection of the MoKα_2 line by rock salt.
2θ = angle of scattering from the sample.

The intensity curves are put upon an absolute basis by expressing them in electron units per arbitrary unit of composition. Representing any composition as $(Na_2O)_x\ (SiO_2)_{1-x}$, the number of atoms of each kind in the arbitrary unit of composition is taken as $(2x)$ Na, $(1-x)$Si, and $(2-x)$ 0.

If there were no interference effects and all atoms scattered independently, the total X-ray scattering would be the sum of the unmodified and the Compton modified scattering.

Unmodified $= 2xf_{Na}^2 + (1-x)f_{Si}^2 + (2-x)f_O^2$.

Modified $= 2xi_{Na} + (1-x)i_{Si} + (2-x)i_O$.

f = atomic scattering factor.
$i = Z - \Sigma f_n^2$ = intensity of modified scattering in electron units.

Both of these quantities are available in tabulated form.[3]

At large values of $\frac{\sin\theta}{\lambda}$, the experimental intensity curve must approach independent scattering, that is, approach the sum of the unmodified and modified scattering. The scale of ordinates of the experimental intensity curve is therefore adjusted to make the experimental curve approach the independent scattering curve at large angles. This serves to put the experimental curve upon an absolute basis (electron units per unit of composition).

The final intensity curves are shown in Fig. 2. The continuous transition in the curves with change in composition is quite evident. With increasing soda content, the strong peak at $\frac{\sin\theta}{\lambda} = 0.12$ gradually diminishes, a peak at about 0.18 gradually increases, and a shoulder at about 0.40 disappears. Up to the highest soda content studied (0.356 Na_2O), there are no abrupt changes in the intensity curves.

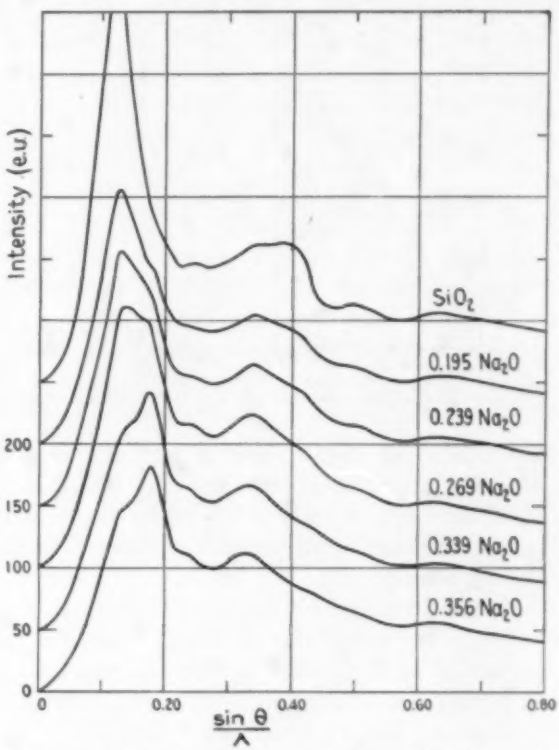

FIG. 2.—X-ray intensity curves for soda-silica glass.

The quantity, $si(s)$, as defined in the introduction, is calculated for each composition from the intensity curve. Plotting $si(s)$ against s, the integration involved in equation (1) is then carried out on the $si(s)$ curve with a harmonic analyzer. For each composition, the integration is carried out for about 30 values of r. The result-

[3] A. H. Compton and S. K. Allison, X-Rays in Theory and Experiment, pp. 781–82. D. Van Nostrand Co., Inc., New York, 1935.

ing values of $\Sigma K_m 4\pi r^2 \rho_m$ plotted against r give the radial distribution curve.

V. Results

The radial distribution curves for the five soda-silica compositions, together with the curve for SiO_2, are shown in Fig. 3. Each of the five curves is really three curves superimposed; the

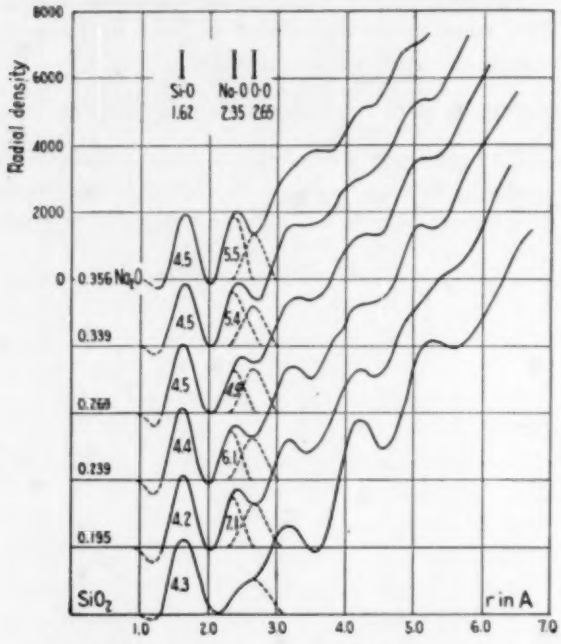

FIG. 3.—Radial distribution curves for soda-silica glass.

distribution of atoms about a sodium, the distribution about a silicon, and the distribution about an oxygen, each of the three component curves weighted by the relative number of atoms of each kind present.

In using the generalized Fourier method, it is necessary to make the approximation that the scattering factors of the different atoms can be expressed as an effective number of electrons times an average f factor per electron. This is not quite true, but the approximation is not bad. The effective numbers of electrons per atom are found to be roughly $K_{Na} = 11.0$, $K_{Si} = 15.2$, and $K_O = 7.3$.

The positions of the peaks on the distribution curves give interatomic distances. By recognizing known interatomic distances from crystal structure studies or from tables of atomic radii, it is possible to identify the two kinds of atoms. If the peak is well enough resolved to measure its area, it is possible to calculate the number of neighboring atoms corresponding to a given peak.

On all six distribution curves, the first peak occurs at about 1.60 to 1.65A. This is the well-known distance of separation of the silicon and oxygen atoms which has been found in all crystalline silicates. The first peak is therefore uniquely identified as due to neighboring oxygens about a silicon and neighboring silicons about an oxygen. If there are n oxygens about each silicon, the area of the peak will be

$$A = (1 - x)K_{Si}nK_O2.$$

The factor, 2, comes from the fact that the area is due to oxygen neighbors about a silicon and also silicon neighbors about an oxygen. The area, A, in electrons squared is obtained by planimetering the curve. For the composition, 0.190 Na_2O (molal), the area is measured as 750 electrons squared.

$$n = \frac{750}{0.81 \times 15.2 \times 7.3 \times 2} = 4.2.$$

The number of oxygens about a silicon, as obtained from the area of the first peak, is given in Fig. 3. The numbers obtained vary from 4.2 to 4.5. Because the silicon atom is found to be tetrahedrally surrounded by 4 oxygens in all crystalline silicates, it is assumed that these values should be interpreted as 4. Owing to the approximations involved in the generalized Fourier method and to the experimental error in the intensity curves, peak areas can not possibly be closer than 10%. The fact that the areas are all somewhat greater than 4 is probably of no significance.

Strictly, the X-ray results prove only that *on the average* each silicon is surrounded by 4 oxygens. The tetrahedral bonding of silicon to 4 oxygens in all crystalline silicates, however, is definitely established. From these results, the conclusion is justified that in the glass *each* silicon is tetrahedrally surrounded by 4 oxygens.

In the soda-silica glasses, the number of oxygens is greater than twice the number of silicons. It is not possible, therefore, for each oxygen to be bonded between 2 silicons as was the case for SiO_2. Part of the oxygens must be bonded between 2 silicons and part only to 1 silicon.

The next larger interatomic distances to be expected in the glass are the Na-O and O-O distances. The ionic radii for silicate structures are Na^+ $r = 0.98$A, $O^=$ $r = 1.32$A. The expected interatomic distances will be Na-O = 2.30A and

O-O = 2.64A. From the composition, the average number of oxygen neighbors which each oxygen should have may be calculated. In SiO_2, for example, it will be 6, because each oxygen is part of 2 tetrahedral groups each containing 3 other oxygens at the distance 2.64A. The peak which is to be expected from the oxygen-oxygen separation is therefore calculated for each composition and drawn on the distribution curve at $r = 2.64$A. Subtracting this peak from the experimental distribution curve, there remains for each of the soda-silica curves a peak at about 2.35A. Because this is just about the Na-O distance, the residual peak is interpreted as due to the Na-O separation. From the area of the peaks, the number of oxygens about each sodium may be calculated. The values are given on Fig. 3, and it is seen that they vary between 4.9 and 7.1, with an average value of 6. The correctness of this interpretation of the Na-O peak is double-checked by two facts, *viz.*, (1) the residual peak comes at the right distance and (2) an average coördination number of 6 for oxygens about sodium is just about what would be expected in a silicate. Because the values are obtained as differences, the accuracy is even lower than for the Si-O peak, and the variations probably have no significance.

The next larger distance of separation will be silicon-silicon. Assuming that the two silicon bonds to an oxygen are roughly diametrically opposite, this distance should be twice the silicon-oxygen distance, or about 3.2A. In SiO_2, a strong peak at 3.2A is clearly shown. With decreasing silica content, this peak is less clearly defined, and at the highest soda content (0.356 Na_2O), the Si-Si peak is masked by a variety of other interatomic distances.

VI. Discussion

From the radial distribution curves, it is possible definitely to rule out certain types of hypothetical structures for soda-silica glass. It is uniquely established that soda-silica glass is not a mixture of SiO_2 and Na_2O molecules. If the silicon of the glass existed only in the form of SiO_2 molecules, O = Si = O, then each silicon would have 2 oxygen neighbors, and the area of the first peak on the distribution curve would be only half the value which has been found experimentally. The nonexistence of the SiO_2 molecule of course is not peculiar to glass. The X-ray determinations of the crystalline structures of silica and silicates[4] have thoroughly established the universal nonexistence of the SiO_2 molecule as a physical reality in crystalline silicates. The tetrahedral bonding of each silicon atom to 4 surrounding oxygens in all condensed forms of silica, in all crystalline silicates, and in silicate glasses is one of the most fundamental laws of modern structural silicate chemistry.

The existence of discrete disilicate molecules, $Na_2Si_2O_5$, can also be ruled out. In order that such a discrete molecule should exist and have both silicons surrounded by 4 oxygens as demanded by the distribution curves, it would be necessary for 3 of the oxygens to be shared between the 2 tetrahedral groups. This would mean that 2 silicon-oxygen tetrahedral groups share a face. It is a fundamental and well-established rule of structural silicate chemistry that 2 silicon-oxygen tetrahedra never share more than one oxygen between them; that is, they share corners, but never edges or faces. The existence, therefore, of discrete $Na_2Si_2O_5$ molecules can be ruled out.

The metasilicate molecule, Na_2SiO_3, could not exist as single discrete molecules because each silicon would have only 3 oxygen neighbors rather than 4, as demanded by the distribution curves. Simple discrete molecules, such as SiO_2, Na_2O, $Na_2Si_2O_5$, and Na_2SiO_3, are all uniquely ruled out by the distribution curves and by the well-established laws of structural silicate chemistry.

One might well ask at this point as to whether there is any significance to talking about compounds in a soda-silica glass. For example, under what conditions would there be any meaning to calling a soda-silica glass a mixture or a solid solution of silica and sodium metasilicate?

In a true solution, the term "compound" has significance if definite discrete molecules exist. For example, a solution of benzene and cyclohexane is more than just a solution of carbon and hydrogen. It is a solution of the two compounds, *benzene* and *cyclohexane*, because the two definite molecules, C_6H_6 and C_6H_{12}, exist. Unless definite molecules exist there is no meaning to the term "compound" in a true solution.

Without simple discrete molecules, soda-silica glass might still be referred to as a mixture of the compounds, silica and sodium metasilicate, if the

[4] W. L. Bragg, Atomic Structure of Minerals. Cornell University Press, Ithaca, N. Y., 1937.

glass is not a true solution. If the glass were a solid mixture of small *crystals* of silica and sodium metasilicate, then reference could certainly be made to these compounds in the glass. One could also speak of compounds, if highly polymerized molecules existed in the glass, so that, for example, certain regions of appreciable volume had the composition SiO_2 and other regions the composition Na_2SiO_3. In either case, the glass would be essentially an emulsion rather than a true solution.

The distribution curves of Fig. 3, obtained by the Fourier analysis, will not distinguish between the possibility of a soda-silica random network or a mixture of crystallites of silica and sodium metasilicate. If, however, the diffraction patterns are interpreted to be caused by crystallites, crystal dimensions[5] of the order of one unit cell are calculated. Because the essential feature in a crystalline structure is regular repetition, the term "crystalline" ceases to have any meaning when applied to volumes of the order of one unit cell.

The X-ray results do not exclude the existence of a few small crystals in a glass. Here and there, as part of a continuous variety of structures, a particular kind of structure might develop far enough to be called a crystal. The essential point is that true glass is a form of matter which has cooled too rapidly from the melt to allow enough systematic organization of the atoms to produce any *appreciable* amount of material that can be called crystalline.

Figure 4 represents schematically in two dimensions the structure of soda-silica glass as deduced from the present X-ray study. Because the real structure exists in three dimensions, it is necessary to take certain liberties in making a schematic two-dimensional representation. In three dimensions, each silicon is tetrahedrally surrounded by 4 oxygens, and in the two-dimensional representation each silicon is shown surrounded only by 3 oxygens. The oxygens are correctly represented, some of them bonded between 2 silicons, and others bonded only to 1 silicon. The sodium ions Na^+ are shown in various holes in the irregular silicon-oxygen network. This figure represents very well the essential scheme of structure in a soda-silica glass. There is a definite scheme of coördination; each silicon tetrahedrally surrounded by 4 oxygens and part of the oxygens bonded between 2 silicons and part only to 1 silicon. The sodium ions are held rather loosely in the various holes in the silicon-oxygen network and are surrounded on the average by about 6 oxygens. Although it is a perfectly definite scheme of structure, there is no regular repetition in the pattern and the structure is noncrystalline.

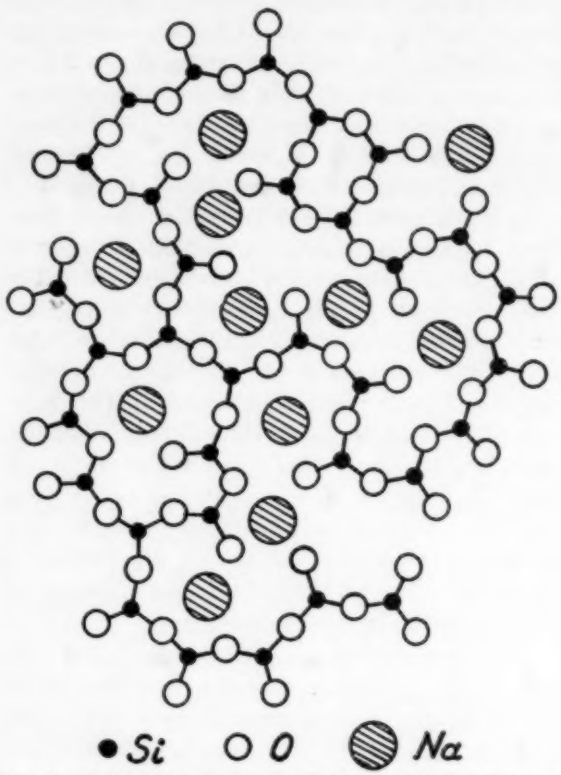

FIG. 4.—Schematic representation in two dimensions of the structure of soda-silica glass.

Because there is no regular repetition, it is evident why soda-silica glass has no definite chemical composition. Starting with vitreous silica, there is a random network in which each silicon is tetrahedrally surrounded by 4 oxygens and each oxygen is bonded between 2 silicons. As the soda content is increased, the number of oxygens becomes greater than twice the number of silicons, and hence more and more of the oxygens are bonded only to 1 silicon. The sodium ions take the best places they can find in the various openings in the silicon-oxygen network.

[5] If one tries to interpret the X-ray pattern of vitreous SiO_2 as due to small crystals of cristobalite, one calculates from the peak breadths a crystallite dimension of 7.7A. This value is scarcely larger than the size of the unit cell of cristobalite, 7.0A. See B. E. Warren and J. Biscoe, "Structure of Silica Glass by X-ray Diffraction Studies," *Jour. Amer. Ceram. Soc.*, 21 [2] 49–54 (1938).

Electrical conduction is readily understood in terms of Fig. 4. Owing to the temperature motion, the atoms of the silicon-oxygen network are oscillating about mean positions. Under the influence of the electric field, the loosely bound Na^+ ion falls step-fashion from one network hole to another as conditions make the step possible.

The lowering of the softening temperature of silica glass by addition of soda is also understood from Fig. 4. In vitreous silica there is a complete system of bonding in three dimensions, each silicon to 4 oxygens and each oxygen to 2 silicons. With the addition of soda, breaks occur in the silicon-oxygen framework due to some of the oxygens being bonded only to one silicon. With more and more breaks in the strong silicon-oxygen network, the structure is no longer rigidly braced in three dimensions. Displacements and changes in configuration in the silicon-oxygen network can take place at temperatures which are still too low for disrupting any appreciable number of silicon-oxygen bonds.

Because there is no scheme of repetition in the glass, no two points are exactly identical. There are points with widely varying degrees of weakness, at which flow or breaking can occur at a continuous variety of temperatures. It is readily understood, therefore, why glass gradually softens, rather than having a definite melting point like a crystal.

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July, 1938
17—7

Abrasives

Application of the diamond wheel to the grinding of cemented carbides. W. T. McCargo. *Machinery* [N.Y.], **44**, 96–99 (1937).—The following general rules apply to the grinding of cemented carbides by means of a vitrified wheel: (1) select a very soft wheel which will provide the necessary resharpening action during the grinding operation; (2) dress wheels frequently to prevent glazing; (3) use very light pressures for off-hand grinding or very small down feed with rapid transverse speeds across the entire face for machine grinding; (4) in off-hand grinding operations, keep the tool constantly in motion; (5) always grind against the cutting edge from the tip toward the body or shank of the tool; (6) in off-hand grinding, use fixtures or pedestal-type supports wherever possible; (7) keep the wheel spindle snug and free from vibrations to prevent chipping the carbide; (8) grind on the periphery of straight wheels for removing large amounts of stock; (9) in free-hand grinding, grind alternately on the carbide and the steel shank to present small areas of contact to the wheel face; (10) leave a very small land after the roughing operation, and be sure the roughing cut is never taken to the very edge of the tool, since this tends to chip the cutting edge; and (11) on large areas of contact, hollow-grind the body of the surface first, and then finish on the side of a cup wheel. Diamond wheels are now developed and are especially useful in dressing small-sized tools. Elimination of chipping and cracking and a longer tool life result with the use of the diamond wheel. C.B.J.

Binding agents of polishing pastes. A. Pollack. *Oberflächentech.*, **15** [8] 79–80 (1938).—Binding agents are defined as the sum of all organic substances added to grinding and polishing pastes which do not exert a polishing or grinding effect but serve to hold the powdery or granular polishing agent together. They consist of the actual binders, hardening substances, softening substances, lubricating agents, means for reducing the melting point of the binder, and substitutes for cheapening. The various groups are described in detail. Stearic acid is the principal binding substance, beeswax or carnauba wax the principal hardener, and vaselines or fats the principal softeners. The melting point of stearic acid is 69°, of tallow 45°, of waxes 40° to 60°, and of paraffin 45° to 55°C. Recipes for various purposes are included. M.H.

Efficiency in the polishing and buffing room. L. R. Eastman. *Metal Cleaning & Finishing*, **9** [7] 599–605 (1937).—The principal factors affecting efficient polishing or buffing operations are (1) working conditions, (2) equipment, (3) materials, (4) sequence of operations, (5) uniformity, and (6) the human element. The essential details governing the selection of the proper buffing composition are enumerated, and the raw materials used in compounding the compositions are discussed. Methods of testing buffing compositions and the relation between buff wear and type of composition are discussed in detail. E.J.V.

Finishing cylindrical work by burnishing rollers. R. K. Kennedy. *Machinery* [N. Y.], **43**, 642–43 (1937).—Stellite rollers are used for finishing locomotive and car journals, piston rods, and crankpins. Efficiency is increased and maintenance is decreased. A high degree of smoothness is obtained, and filing is entirely eliminated. C.B.J.

Finishing gray and malleable iron, steel, steel forgings, and nickel or chrome alloys. Theodor C. Eichstaedt.

Metal Cleaning & Finishing, **9** [10] 873–76 (1937).—Grinding, the process of smoothing and snagging castings, forgings, and stampings, is done on a solid abrasive wheel made from all sizes of grain abrasives, Nos. 16 to 180. Polishing is the process of smoothing by means of grain abrasives of different sizes according to the finish required, the abrasive being applied to belts and wheels with glue or cement. Buffing, the process of bringing a high luster to surfaces that have been wet polished on a polishing wheel or belt, is done on a cloth, felt, sheepskin, or chamois-skin wheel. The abrasive used for buffing is fine and not hard enough to leave scratches in or on the surface of the article polished. Detailed descriptions of these methods are given. E.J.V.

Measuring plated and polished surfaces. S. Bousky and E. J. Abbott. *Metal Cleaning & Finishing*, **9** [5] 425–28 (1937).—The Profilometer is a portable instrument which enables the operator to make surface-roughness measurements rapidly, a continuous running average of the surface roughness being read directly on a meter which is calibrated in microinches. The most useful specification of surface finish appears to be in terms of the dimensions of the surface irregularities. Examples of successful applications of the Profilometer are cited. See *Ceram. Abs.*, **15** [5] 139 (1936). E.J.V.

Nature of the polish layer on metals. Mervyn L. Smith. *Metal Cleaning & Finishing*, **9** [9] 783–87 (1937).—Application of modern scientific methods to the study of polishing shows great possibilities in control of the polish layer in improving corrosion resistance, hardness, imperviousness, and other desirable surface properties. The distribution of atoms in the polish layer is the type found in supercooled liquids or glasses, best described by the term "vitreous." Analysis of the polish layer by use of the electron-diffraction camera and tests in which a layer of crystals of one metal was deposited by condensation onto the surface of another metal revealed the essentially liquid nature of the Beilby layer. In polishing, the surface of lower melting point actually melts. True polishing can occur only when the polishing agent has a higher melting point than the surface and when the practical conditions are such that sufficient heating occurs. The Beilby layer contains a most complicated mixture of atoms: some of the abrasive agent, absorbed foreign substances, and, in particular, oxides of the metals concerned. Since oxides frequently form good protective coatings, this is a factor in promoting corrosion resistance. The hardness of a metal is usually increased on polishing. The thickness of the Beilby layer depends on the degree of working; in general it amounts to a few hundred-thousandths of a millimeter. The polishing process should aim at establishing the coherent polish layer in a condition as suitable as possible with the least expenditure of time and labor. E.J.V.

Physical properties of surfaces: I, Kinetic friction. W. G. Beare and F. P. Bowden. *Trans. Roy. Soc.* [London], **A234**, 329–54 (1935).—From measurements of kinetic friction between highly polished surfaces it has been found that with unlubricated surfaces, the coefficient μ_k is independent of the load, the area of contact, and the velocity. With lubricated surfaces a transition from "fluid lubrication" to "boundary lubrication" is shown. The effect of chemical composition on μ_k is investigated for homologous series of hydrocarbons, alcohols, and acids. **II, Viscous flow of liquid films. Range of action of surface forces.** S. H. Bastow and F. P. Bowden. *Proc. Roy. Soc.* [London], **A151**, 220–33 (1935).—Measurements on the viscosity of very thin liquid films from 10^{-5} cm. to any desired thickness indicate that the viscosity of the film is the same as that of the liquid in bulk. No evidence was found for rigid oriented chains of molecules. **III, Surface temperature of sliding metals. Temperature of lubricated surfaces.** F. P. Bowden and K. E. W. Ridler. *Ibid.*, **A154**, 640–56 (1936).—A method for measuring the surface temperature of sliding metals is described. The temperature reached depends on the load, speed coefficient of friction, and thermal conductivity of the metals. With easily fusible metals, the surface temperature attained corresponds to the melting point of the metal. With less fusible metals, the local surface temperature may exceed 1000°C. Even with lubricated surfaces the temperature is high and may exceed 600°C, leading to local volatilization and decomposition of the lubricant and breakdown of the boundary film. For Part **IV** see *Ceram. Abs.*, **17** [3] 92 (1938). A.P.

Polishing of cast brass, bronze, copper, and aluminum. Theodor C. Eichstaedt. *Metal Cleaning & Finishing*, **9** [12] 1025–28 (1937).—Before polishing, all brass and bronze castings should be either sandblasted, tumbled, or bright dipped in order to remove all sand from them. The first polishing operation is done on 80-grain, with 140-grain and plenty of grease stick in the fine-wheeling operation. A sewed buffing wheel is generally used, with a carefully selected buffing composition applied without excessive pressure. Cast aluminum may be roughed with 120-grain abrasive and fine wheeled with 180-grain, but if the castings are from a job foundry, three operations may be necessary, using first 60- or 80-grain, then 140- or 150-grain, and finally 180- or 200-grain. In polishing cast copper, an abundance of grease must be applied to grinding wheels and very little pressure used. If 60-grain is used in the first operation, 120 is used for the second and 140 to 180 for the last. E.J.V.

PATENTS

Abrading apparatus. W. L. Keefer (Pangborn Corp.). U. S. 2,116,153, May 3, 1938(Sept. 2, 1937). In an abrading apparatus, a structure mounted for rotation at high speed, the structure providing a generally annular surface facing toward the axis of rotation of the structure, means for depositing abrasive upon the surface, and discharge means for dislodging the deposited abrasive from the surface at a predetermined point in the rotation of the structure for projecting the abrasive at an abrading velocity.

Abrading wheel sheet and sheet holder. H. W. Dempsey (H. F. Hittle). U. S. 2,115,943, May 3, 1938 (July 11, 1936; renewed March 26, 1937).

Abrasive. E. E. Plotkin. Russ. 45,512, Dec. 31, 1935; *Chem. Abs.*, **32**, 3114 (1938).—A mixture of Al_2O_3 with about 1.5% Sb and 0.75% wood charcoal is fired at about 1700°.

Abrasive. B. Sinay and M. Mendelson. Belg. 420,354 and 420,355, April 30, 1937; *Chem. Abs.*, **32**, 2705 (1938).—Diamond fragments or dust is mixed with

a finely divided alloy, and the mixture is heated to the aggregation temperature of the alloy. In Belg. 420,355, diamond fragments or dust are dispersed in a molten metal (steel, alloy steel, or W alloy).

Abrasive article. C. E. WOODDELL, C. S. NELSON, AND ROY LINCOLN (Carborundum Co.). U. S. 2,115,897, May 3, 1938 (May 15, 1935). An abrasive article comprises a flexible band and a plurality of blocks of bonded abrasive material attached to the band by a resin layer.

Abrasive cutting-off or severing machine and wheel. H. G. ROBINSON. Brit. 482,528, April 13, 1938 (Nov. 6, 1935).

Abrasive device. A. W. WALKER (Carborundum Co.). U. S. 2,114,410, April 19, 1938 (Dec. 23, 1935).

Abrasive disks with a vulcanite binder. P. M. KRYMOV. Russ. 45,181, Nov. 30, 1935; *Chem. Abs.*, **32**, 3115 (1938). —The disks are pressed from a material ground to the required grain size and passed through a sieve.

Abrasive polishing materials. R. S. EDWARDS (Rumford Chemical Works). U. S. 2,115,197, April 26, 1938 (Aug. 23, 1937). An abrasive consisting of fine substantially uniform grains of gypsum material containing phosphoric acid and an alkaline phosphate in an amount sufficient to act as an inhibitor of anhydrite recrystallization to preclude dissociation of the anhydrite when it is calcined at temperatures between 1800° and 2300°F.

Abrasive wheel. A. W. MALL. U. S. 2,116,272, May 3, 1938 (Oct. 26, 1936). D. E. MULHOLLAND (General Abrasive Co., Inc.). U. S. 2,115,210, April 26, 1938 (Jan. 22, 1935; renewed Aug. 7, 1937).

Abrasive wheel and method of making. A. G. SCUTT AND A. L. BALL (Carborundum Co.). U. S. 2,117,513, May 17, 1938 (Nov. 27, 1935). An abrasive article comprises particles of hard abrasive, a filler of condensation resin that was cured to a substantially infusible condition and comminuted before admixture with abrasive particles, and a binder of synthetic resin cured in intimate contact with the abrasive particles and the precured resinous filler.

Abrasive wheel and method of using. D. E. MULHOLLAND AND W. S. MULHOLLAND (General Abrasive Co., Inc.). U. S. 2,115,209, April 26, 1938 (July 11, 1934).

Abrasive wheel mount. THURE LARSSON (Norton Co.). U. S. 2,115,683, April 26, 1938 (June 11, 1936).

Abrasive wheels. V. G. KAZANTSEV. Russ. 45,510, Dec. 31, 1935; *Chem. Abs.*, **32**, 3115 (1938).—Abrasive wheels are cast centrifugally by introducing the mass with the binder through the hollow shaft of a rotating mold.

Adjusting means for honing tools. K. W. CONNOR AND ALBERT BLEASDALE (Micromatic Hone Corp.). U. S. 2,116,925, May 10, 1938 (Oct. 7, 1935).

Angle grinding spindle. A. W. MALL. U. S. 2,116,491, May 3, 1938 (Dec. 19, 1936).

Automatic cam grinding machine. H. A. SILVEN AND C. G. FLYGARE (Norton Co.). U. S. 2,117,916, May 17, 1938 (Dec. 26, 1935).

Automatic grinding machine. H. A. SILVEN (Norton Co.). U. S. 2,117,917, May 17, 1938 (Oct. 4, 1937).

Circular relief grinder. C. E. WALLING. U. S. 2,117,637, May 17, 1938 (Sept. 5, 1935).

Composition of matter and method of manufacturing. C. S. NELSON (Carborundum Co.). U. S. 2,114,636, April 19, 1938 (March 11, 1935). An abrasive article comprises abrasive grains and a bond therefor comprising a hardened rubber derivative which was rendered irreversibly liquid by heat alone prior to hardening.

Curved abrasive fabric. R. C. BRYANT (Carborundum Co.). U. S. 2,115,904, May 3, 1938 (Oct. 4, 1934; renewed Oct. 4, 1937).

Ebonite abrasive disks. P. M. KRYMOV. Russ. 45,067, Nov. 30, 1935; *Chem. Abs.*, **32**, 3116 (1938).—Rubber is mixed in calenders with S, fillers, and abrasive material (powdered), and the mixture is passed through a metallic sieve. The powder is finally pressed in molds.

Electrically operated stop mechanism for automatically arresting the operations of grinding machines and other machine tools. J. LUND, LTD., AND J. D. SCAIFE. Brit. 482,741, April 21, 1938 (Aug. 31, 1936).

Footstock for cam lapping machines. H. S. INDGE AND G. E. HULBERT (Norton Co.). U. S. 2,117,960, May 17, 1938 (Aug. 21, 1936; May 27, 1937).

Grinding or abrading machines. HEALD MACHINE CO. Brit. 483,279, April 27, 1938 (March 11, 1936).

Grinding machine. A. G. BELDEN (Norton Co.). U. S. 2,115,678, April 26, 1938 (Oct. 7, 1935). E. A. HALL (Hall Mfg. Co.). U. S. 2,116,498, May 10, 1938 (Oct. 14, 1936). E. H. ODOM (Simplicity Mfg. Co.). U. S. 2,116,686, May 10, 1938 (April 15, 1936). WILLIAM OGILVIE (B. S. A. Tools, Ltd.). U. S. 2,117,979, May 17, 1938 (April 4, 1936). H. J. PERAZZOLI. U. S. 2,114,454, April 19, 1938 (Oct. 28, 1935).

Honing machine. A. M. JOHNSON (Barnes Drill Co.). U. S. 2,114,349, April 19, 1938 (June 29, 1936).

Hydraulic wheel feed. A. G. BELDEN AND R. A. COLE (Norton Co.). U. S. 2,113,367, April 5, 1938 (July 1, 1936).

Lawn mower grinder. K. H. SELIN. U. S. 2,116,414, May 3, 1938 (May 22, 1937).

Lens grinding machine. C. E. EVANS. U. S. 2,112,836, April 5, 1938 (Sept. 8, 1932).

Machine for grinding cylindrical and external surfaces. ALBERT BLEASDALE (Micromatic Hone Corp.). U. S. 2,116,922, May 10, 1938 (Oct. 26, 1935).

Machine for grinding screw threads. HERBERT LINDNER. U. S. 2,116,031, May 3, 1938 (Dec. 21, 1934).

Making preformed abrasive articles. E. S. MERRIAM. U. S. 2,117,970, May 17, 1938 (July 21, 1936). A process for producing preformed abrasive articles comprises mixing suitable abrasive grains, a previously fused vitreous bonding material in finely divided form fitted, upon being re-fused, to effectively bond the abrasive grains, and a temporary binder, molding the mixture into the desired form, placing the resultant green article in a suitable retort and embedding it therein in a mass of granular material inert at the temperature required to re-fuse the vitreous bonding material, with which granular material there has been mixed a substantially nonresidue-producing combustible material sufficient in amount to generate, when burned in the retort, adequate heat to fuse the vitreous bonding material in the article, and igniting and burning the combustible material and controlling the cooling of the articles by circulating a current of a gaseous cooling medium through the retort.

Making shaped bodies from hard substances. PAUL MARTH. U. S. 2,116,399, May 3, 1938 (Nov. 24, 1936).

Manually portable motor driven polisher. J. C. HARDY. U. S. 2,115,812, May 3, 1938 (Oct. 7, 1936).

Method and apparatus for finishing brake shoes. H. K. BIGELOW (B. S. Lurie). U. S. 2,118,003, May 17, 1938 (March 20, 1936).

Polishing machine. EDMUND HARTMANN (Junkers Flugzeug- und Motorenwerke A.-G.). U. S. 2,115,461, April 26, 1938 (Dec. 1, 1936).

Portable polishing machines. BRIGGS MFG. Co. Brit. 483,596, May 4, 1938 (Feb. 19, 1936).

Preparing a surface. D. A. BOSLEY, JR. (Glidden Co.). U. S. 2,117,289, May 17, 1938 (May 26, 1933; Dec. 17, 1934). The method of preparing a surface consists in applying a primer containing as an essential ingredient a pigment as hard as or harder than silicon carbide (Carborundum) and aluminum oxide (Alundum), applying over the primer a sanding surfacer, drying the surfacer, and smoothing the surface with an abrasive which will abrade the surfacer without substantially affecting the primer.

Producing silicon ware. MAX HAUSER. U. S. 2,112,777, March 29, 1938 (June 10, 1936). In the manufacture of articles of ceramic ware of which silicon is an essential constituent, the step comprises firing the shaped articles between 1250°C and the softening point of the article in an atmosphere practically devoid of oxygen.

Roll grinding machine and method. C. A. FOX. U. S. 2,115,908, May 3, 1938 (June 15, 1935).

Work-supporting roll for polishing machines. A. J. SANDORFF (General Abrasive Co., Inc.). U. S. 2,115,217, April 26, 1938 (Dec. 18, 1935).

Art and Archeology

American ornamental porcelain. MARY FANTON ROBERTS. *Arts & Dec.*, **47** [4] 26–27, 48 (1937).—Only recently has America produced glazed pottery that promises to take its place in world markets. While it is still inferior to rare specimens imported from the Orient, its qualities are noteworthy. Several groups of figures by outstanding designers are cited. Illustrated. L.F.M.

Bohemian glass. ANON. *Arts & Dec.*, **47** [6] 21 (1938).—Modern glass produced in Czechoslovakia shows originality and distinction. Illustrated. L.F.M.

Capo di Monte porcelain. ANON. *Arts & Dec.*, **45** [2] 20 (1936).—Many museums and royal collections contain examples of porcelain produced at Capo di Monte early in the 18th Century under the patronage of Charles III of Naples. Illustrated. L.F.M.

Ceramic figures by Jean Manley. ANON. *Arts & Dec.*, **48** [1] 14–15 (1938).—Extraordinary results have been obtained by J. Manley through her unique groupings and compositions. Using native California clay and a palette of simple colors, she has created strikingly realistic figures. There is no duplication in her pieces and the majority are pastoral in subject. Illustrated. L.F.M.

Chinese teapots. JANE SHERRARD. *Arts & Dec.*, **47** [6] 12–13, 48 (1938).—Chinese teapots in the Edna H. Kern collection date from the 15th to 18th Century; all are unique in design and form. Illustrated. L.F.M.

Chinese terra cotta horses. ANON. *Arts & Dec.*, **48** [3] 21 (1938).—Animals in gray clay, painted in rich colors, were produced during the T'ang dynasty. The figures of horses are imparted with great vigor and movement and are not as delicate as those of the Ming dynasty. Illustrated. L.F.M.

Collecting English pottery. ARTHUR HAYDEN. *Arts & Dec.*, **48** [3] 18–20 (1938).—The price of English pottery has prevented many small collectors from entering this field. Careful study and expert advice will aid in identifying many pieces that can be bought for a reasonable sum. Illustrations and markings are discussed. L.F.M.

Colors on glazes for decorative ceramics. J. LIEBSCHER. *Stavivo*, **1937**, p. 163.—Decorative ceramic ware in Czechoslovakia is usually made from potter's clays and limy loams with additions of chalk or lime marl. The stannic glazing used is fired at 800° to 1000°C. The following colors are generally used: yellow, $KHSbO_3$ and ZnO; coral red, $30PbO + 10\ SiO_2$ (to 100 d. of the flux are added about 60 d. of the chromium red); blue, CoO–ZnO fused at 1000°C; green, CuO fused in a lead flux or CrO_3 in a lead-borax flux; turquoise, CrO_3–CoO (only about 1 to 1.5% of this compound is added to 100 d. of flux); and brown, 3 d. MnO_2 + 2 d. $ZnSO_4$. R.B.

Crystal containers for perfume and powder. ANON. *Arts & Dec.*, **45** [3] 44 (1936).—Seven modern containers for cosmetics are described and illustrated. L.F.M.

Decorative ceramics in Czechoslovakia. R. BARTA. *Keramický Obzor*, **1937**, No. 3, p. 4.—Ceramics were made in the territory of the present Czechoslovak Republic as early as the Stone Age, about 15,000 years before Christ. The potter's wheel was introduced in the 5th Century B.C. Ceramic art of the Middle Ages is characterized by Byzantine Christianity in the first period and by Roman Christianity in the 9th and 10th Centuries. Glazed ware was manufactured in the 13th Century, and in the Hussite period it had its greatest development. The Anabaptists introduced the manufacture of faience in Czechoslovakia ("Faenza—," *Ceram. Abs.*, **14** [3] 60 (1935); "Pottery—," *ibid.*, **17** [5] 171 (1938)). They laid the foundation for the so-called peasant ceramics, *i.e.*, in the 17th Century, the jugs, pierced trays, "shawls," etc.; it was at a later period that this fashion was imitated by the common people. Peasant ceramics, however, underwent local and Turkish influence. According to some scholars, the gay dressing of the Osmany was of Slavonic origin, through a Constantinople architect, Sinan, who is believed to have been of Czechoslovak origin. The first Bohemian porcelain was produced in 1790 at Rabensgrün near Karlovy Vary and in 1792 at Slavkov, also near Karlovy Vary. Fashions characterizing porcelain also influenced the production of useful and decorative ceramics. Illustrated. R.B.

Decorative glassware. ARTHUR H. TORREY. *Arts & Dec.*, **46** [6] 26–27 (1937).—T. describes unusual pieces of ornamental glassware showing the relation between design and form. A typical example is the massive crystal vessel engraved with a heroic figure. Glassware having cameo effects is obtained by cutting to various depths

glassware formed by casing amber and deep blue over the original white object. Illustrated. L.F.M.

Discoveries at Velehrad. ANON. *Národní Listy*,-April 2, 1937.—Under the guidance of the Bureau for the Maintenance of Historical Monuments, remains of Roman buildings have been discovered at the old Slavonic fortification, Velehrad, in Moravia. Both glazed and unglazed tile were found dating from the founding of the Velehrad Monastery (1202), the Hussite era (1421), and the Renaissance (1587 and 1630). R.B.

Madonnas in porcelain. ANON. *Arts & Dec.*, **45** [4] 12–13 (1936).—Brilliant colors are predominant on figures of madonnas from nearly all countries. Examples are illustrated and described. L.F.M.

Mary Louise McLaughlin, originator of plastic slip underglaze painting and maker of one-fire porcelain artware. ANON. *Bull. Amer. Ceram. Soc.*, **17** [5] 217–25 (1938).

Modern trends in glass and china. ARTHUR H. TORREY. *Arts & Dec.*, **44** [6] 29–32, 43–44 (1936).—The trend in tableware, both here and abroad, is toward simplicity. Decoration is limited or almost lacking and the beauty lies in the design or the material itself. The survey covers the field from cocktail to formal dinner service. Illustrated. L.F.M.

Modern Venetian glass. ANON. *Arts & Dec.*, **47** [3] 32–33 (1937).—All of the skill which has made Venetian glass so prized for centuries is embodied in the modern production. Tableware, ornamental pieces, and figures are illustrated. L.F.M.

New galleries for Parish-Watson. HELEN COMSTOCK. *Connoisseur*, **101** [440] 207 (1938).—New rooms house an exhibition of Chinese porcelains and an important group of Mohammedan potteries, in which Guebri, Rhages, and Sultanabad types are represented. A photographic reproduction is shown of a Rhages bowl of the 12th to 18th Century, executed in enamel colors on an ivory white ground. Although the design is of a well-known type (king on a throne between two courtiers) it differs from the usual treatment. The painted pottery of the Seljuk rule before the Mongol's victory in 1220 is a supreme example of a purely pictorial style in pottery decoration. Unlike the mural style of the Greek vase painting, the Persians adjusted the pictorial subject matter to the surface and material of the pottery. M.E.P.

Nickel and copper plating of glass and porcelain ware. P. L. VOLODIN AND E. I. BABIEV. *Keram. & Steklo*, **14** [2] 21–24 (1938).—Methods used for metal plating are discussed, including pickling, washing, drying, polishing, and silver, copper, and nickel plating of the ware. M.V.C.

Persian bowl. ANON. *Connoisseur*, **101** [440] 214 (1938).—Full page illustration in color from Eumorfopoulos Catalogue by permission of Ernest Benn, Ltd. This conical bowl is of red ware with a wash of white slip and graffito designs inside under a green glaze; it is decorated with an eagle with wings outspread and floral scrolls, has spur marks inside, and is of the Zejan type of the 10th to 12th Century. M.E.P.

Pictures of the chase on china. LAURA LORENSON. *Arts & Dec.*, **45** [3] 26–27, 53 (1936).—The hunting scenes drawn by J. F Herring, Sr., and John Leech are described and illustrated. These paintings have been used for decorating Spode and Wedgwood china. L.F.M.

Porcelain garniture from Vincennes. HELEN COMSTOCK. *Connoisseur*, **101** [440] 209 (1938).—The soft paste of Vincennes is important as a predecessor of Sèvres and it represents a brief but fine period. A reproduction of three vases in ivory white paste decorated in gold and high relief design of swans and reeds is shown. Rich and delicate flowers, a specialty of this factory, were fashionable in 1750 when the King ordered them for Madame de Pompadour. Pieces requiring sculptors' models brought the services of the King's jeweler, Duplessis. The marks of this factory show the royal patronage by the interlacing L's, and after 1753 date letters beginning with A started. D, 1756, marks the removal to new quarters and the inauguration of Sèvres. M.E.P.

Sculptured crystal tables. ALICE BOWEN. *Arts & Dec.*, **47** [4] 10–13 (1937).—The beauty and romance of Hawaii have been captured and expressed in the form of sculptured crystal tables. Using the exotic floral designs of this region, the designers have achieved a richness that is truly tropical. Illustrated. L.F.M

Sèvres porcelain. EUGÈNE MARSAN. Translated in *Arts & Dec.*, **47** [2] 19–21, 41 (1937).—The last fifteen years have witnessed remarkable changes in production, form, decoration, and ceramic materials at Sèvres. The factory, the school, the museum, and the ceramic institute function as one unit. Production covers a broad field from tile to artificial teeth. The ornamental pieces have taken on new elegance, making this one of the finest periods in the history of porcelain. Illustrated. L.F.M.

Slovak ceramics in Prague. RUDOLF BARTA. *Slavivo*, **1937**, p. 204.—The oldest cockles exhibited are those of Bánská Bystrica from the year 1500. The green baroque cockle with the relief of St. Andrew is from Modrá and dates from 1628. The oldest Haban ceramics date from 1630, but there are also ceramics from the year 1565. The exhibition possesses valuable guild jugs from the collection of H. Vaurečka and O. Blažíček in Prague. A separate part of the exhibition consists of the products of a former factory in Galicia and from the city of Košice. City and country ceramics from the year 1720 to 1820 are also richly decorated. The communities of Stupava, Boleráz, Velké Levary, Košolná, Dehtice, and others are represented. R.B.

Unaker clay. MARY F. ROBERTS. *Arts & Dec.*, **44** [2] 26–27, 48 (1936).—To achieve a hard paste surface in porcelain, Richard Champion of England introduced a clay found in South Carolina. This clay, called Unaker, will give a dense and smooth finish to porcelain. Illustrated. L.F.M.

Victoria and Albert Museum. H. GRANVILLE FELL. *Connoisseur*, **101** [440] 211 (1938).—A recent important gift is the hundred specimens from the collection of the late Wallace Elliot, one time President of the Engl.sh Ceramic Circle. The pieces are chosen according to his will by the Keeper of the Ceramic Department, a similar number having been bequeathed to the British Museum. See *Ceram. Abs.*, **14** [8] 180 (1935). M.E.P.

Willems, china modeler. WILLIAM H. TAPP. *Connoisseur*, **101** [440] 176–82 (1938).—T. has found documentary evidence in the archives at Tournai, two of the

London Art Society Catalogues, and the Chelsea Ratebooks, that identifies Joseph Willems and accords him the honor and praise long due him for his work at the Chelsea porcelain factory and at the Tournai factory. Born in Brussels early in the 18th Century, he went to England and worked in the Chelsea factory under Nicholas Sprimont. In 1766 he returned to the Continent and worked at the Tournai Porcelain factory for nine months before his death in 1766. A description, with illustrations and comparisons, is given of figurines which may now be attributed to Willems from several periods at Chelsea and at Tournai. The actual ebb and flow of trade prosperity at the Chelsea factory can be traced by the migration of artists to and from Continental and other English porcelain factories.

M.E.P.

BOOK

Glass and jewelry (Sklo a bijouterie). ANON. Published by National Institute for Technical and Professional Training, 1930. In Czechoslovak, German, French, and English. 30 pp. 50 illustrations.—A short account of the glass industry in Czechoslovakia is given. This industry comprises the leading export trade, and the most important export markets for Bohemian glass are the U. S., Great Britain, and Germany. The manufacture of Jablonec ware, *i.e.*, small decorative glass articles in plain or colored glass, painted, etched, engraved, or cut, is essentially a home industry; it represents a yearly consumption of 900 metric tons of glass rods and tubes. About 1200 enterprises are engaged in the manufacture of glass brooches, necklaces, bangles, etc. Glassworkers are trained in national schools where they are given both a practical and theoretical instruction. The Czechoslovak glass industry employs about 150,000 workers.

R.W.DEVILLERS

PATENTS

Colors for ceramics. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Fr. 818,590, Sept. 29, 1937; *Chem. Abs.*, **32**, 2704 (1938).—Highly dispersed colors for ceramics are prepared by causing a solution of salts, particularly sulfates, of heavy metals such as Ni, Co, Fe, Mn, and Cu to react with an ammoniacal solution of chromates, filtering and drying the precipitate, and calcining at 550° to 650°.

Decalcomania transfer. C. W. STILLWELL (Dennison Mfg. Co.). U. S. 2,115,345, April 26, 1938 (Jan. 7, 1936).—A strip of decalcomania transfers comprises a ribbon of backing material, a coating of adhesive on the ribbon, and a layer of design material adhering to the coating, the layer comprising a series of designs separated by waste zones and the strip having weakened lines at the junctions between the designs and zones, the lines being substantially confined to the layer.

Designs for:

Bottle. JEAN FULCHER (Maryland Glass Corp.). U. S. 109,513, May 3, 1938 (March 2, 1938). H. R. MOTT (Nehi, Inc.). U. S. 109,520, May 3, 1938 (Jan. 29, 1937).

Combination coaster and ashtray. S. F. BOWEN. U. S. 109,510, May 3, 1938 (March 5, 1938).

Glass. MORRIS SHAPIRO. U. S. 109,535, May 3, 1938 (March 15, 1938).

Glass milk bottle. J. H. MEIER (J. T. & A. Hamilton Co.). U. S. 109,518, May 3, 1938 (Jan. 9, 1937).

Goblet. R. A. KELLY (United States Glass Co.). U. S. 109,406, April 26, 1938 (Dec. 20, 1937). R. R. KOSTELLOW (United States Glass Co.). U. S. 109,486 and 109,487, May 3, 1938 (Feb. 16, 1938). U. S. 109,530, May 3, 1938 (Feb. 23, 1938). U. S. 109,662, May 10, 1938 (Feb. 9, 1938).

Jug. R. R. KOSTELLOW (United States Glass Co.). U. S. 109,484, May 3, 1938 (Feb. 5, 1938).

Plate. KISABURO KATO. U. S. 109,529, May 3, 1938 (Dec. 15, 1937). C. W. LEIGH (Morimura Bros., Inc.). U. S. 109,490 to 109,494, May 3, 1938 (Feb. 11, 1938). VICTOR SKELLERN (Josiah Wedgwood & Sons, Inc.). U. S. 109,506 and 109,536, May 3, 1938 (March 2, 1938).

Saucer. GISELA WOOD. U. S. 109,508, May 3, 1938 (April 24, 1937).

Tumbler. T. D. SAUNDERS (Dunbar Glass Corp.). U. S. 109,675 and 109,676, May 10, 1938 (March 16, 1938).

Vase. R. R. KOSTELLOW (United States Glass Co.). U. S. 109,483, May 3, 1938 (Feb. 5, 1938).

Water pitcher. R. R. KOSTELLOW (United States Glass Co.). U. S. 109,485, May 3, 1938 (Feb. 5, 1938).

Machine for applying decalcomanias. F. X. MALOCSAY. U. S. 2,117,618, May 17, 1938 (July 21, 1937).

Cements

Cements and putties for chemical work. A. G. WRIGHT. *Chem. Age* [London], **38** [982] 317–19 (1938).—The chief uses of cements for permanent sealing and joints and of putties for temporary work are noted, but few cements are described. Mixtures of sodium silicate with ground silica, asbestos, pumice, clay, whiting, and crushed brick provide a variety of acid-resisting cements; these can be made to set more quickly by using a filler which reacts with the silicate of soda or by treating the hardened surface with calcium chloride or with sulfuric acid. The sodium silicate recommended has a ratio of $Na_2O:SiO_2 = 1:3.2$ or 1:3.5; the density of the liquid should be 70°Tw. A mixture of fine pumice and sodium silicate solution is claimed to be resistant to sulfuric acid. A mixture of asbestos and sodium silicate solution is resistant to nitric acid, especially if the asbestos has previously been leached with acid and then washed. A mixture of barium sulfate and sodium silicate produces a rapid-setting cement which is hard and strong, highly resistant to chlorine, and of general utility for repairing stoneware. Ordinary silicate cements require 70 to 100 lb. of sodium silicate to each 100 lb. of filler; most of them require a week to set and a month to harden properly. Quicker-setting cements contain a small percentage of acid or fluosilicate or are of the basic type in which alumina or lime is incorporated. Putties are used for nonrigid joints. A mixture of litharge, linseed oil, and flock asbestos requires about a week to set; it resists hydrochloric and nitric acids up to 56% concentration.

A mixture of asbestos, china clay, and boiled linseed oil is resistant to nitric acid of all concentrations. For stoneware in contact with acid, a black putty made of china clay, tar, asbestos, and anthracene oil is recommended. Red lead cement is suitable for acid-resisting iron and all acid-resisting metal-to-metal joints. A mixture of litharge and glycerine can be given varied characteristics, and various fillers may be added to it. To resist sulfur dioxide gas and hot sulfurous acid solutions, a mixture of litharge, silica, and quartz flour is suggested. A rubber putty consisting of masticated rubber, hot linseed oil, and pipeclay makes a very flexible joint. Rubber may also be mixed with Portland cement. Sulfur with sand or other filler, applied hot, is largely used in chemical works. The soaps of heavy metals, mixed with a drying oil, produce a cement resistant to hydrocarbon solvents. A.B.S.

BULLETIN

Use of high-alumina cements in structural engineering. ANON. Published by Institution of Structural Engineers. Price 6d net. Reviewed in *Engineering*, **145** [3759] 101 (1938).—Test methods are described. Limits established for setting are (1) less than $6^1/_2$ hr. for initial set (3 to 6 hr. being normal), and (2) final set less than $1^1/_2$ hr. after initial set. B.C.R.

Enamel

Briggs steel bathtubs annealed in huge atmospheric furnace. C. R. WYLIE. *Iron Age*, **140** [1] 34–37 (1937).—Clean annealing eliminates pickling. The high-temperature zone of the furnace is maintained at 1600° to 1650°F. Insulation consists of $4^1/_2$-in. Corundite ceiling slabs with 6 in. of Wyolite on top and N20 and N16 Armstrong brick on the side walls and bottom. See *Ceram. Abs.*, **17** [6] 212 (1938). E.H.McC.

Determining the softening point of enamel. GERHARD SCHMIDT. *Sprechsaal*, **71** [4] 53–56 (1938).—Methods of computing melting points of enamels from the melting points of the separate components of the enamel always yield too high values greatly deviating from the actual values. It is difficult to find an exact definition of the softening point of enamels. In reality, softening does not correspond to a definite temperature but covers a range of temperatures, and it should be defined by two limits whose values, even for the same enamel, may vary depending on the operating method (rate of melting). The temperature at which the heated enamel becomes plastic is of interest. As a criterion of the softening point of enamel, S. suggests the use of the temperature at which a cylinder of 75 g. weight penetrates to a depth of 1 mm. into the enamel heated at a rate of 5° to 12°C/min. The apparatus is simple and precise and should always be operated at the same rate of heating. Thus, the softening temperature determined at the heating rate of 5° to 12°C/min. is 20° lower than for the same enamel heated at a rate of 20°/min. Generally, the softening temperature increases with increase in rate of heating. The softening temperatures determined by this method are about 60° higher than those obtained by dilatometric measurements and 120° to 130° higher than those determined from curves of expansion. M.V.C.

Furnace conveyers. M. H. MAWHINNEY. *Ind. Heating*, **4** [10] 839–50, 895–902; [11] 955–60; [12] 1051–53 (1937); **5** [4] 304–10 (1938).—M. discusses conveyers used in various types of furnaces, losses incurred due to design and cooling arrangements, and metals employed under different conditions. Installations are illustrated. M.H.

Heat-resisting muffle equipment for vitreous enameling. A. L. FAWKES. *Sheet Metal Ind.*, **11** [121] 466, 473–74 (1937).—F. reviews the recent developments in Great Britain (where the box muffle has maintained favor) in the design of heat-resisting muffle equipment and outlines American and British practice in the use of heat-resisting alloys (in America middle-grade alloys are used, but in Great Britain higher grades are preferred). The essential properties of alloys required by the British enameler are listed as follows: (*a*) the metal of the perrits or frames must resist scaling at temperaturess not less than 1000°C, and the oxide must be strongly adherent with the most rapid alternate heating and cooling; (*b*) the strength must be such that the temperature of operation does not result in deflection under load beyond economic weight-load ratio; (*c*) the alloy must accommodate any warpage due to speeding up of fusing, which probably causes overloading during service; this may be rectified periodically by straightening and welding if necessary; (*d*) where constructed frames entail welding, the alloy must be of a composition which ensures strength each side of the weld equal to that of the weld itself, and the resultant alloy of the weld must conform with the nonscaling properties of the casting. A.P.S.

Nickel dip treatment of enameling iron. JAMES PETTYJOHN. *Metal Cleaning & Finishing*, **9** [12] 995–98 (1937).—A nickel dip is used on enameling iron or steel to (1) reduce copperheading, (2) promote adhesion of the fired ground coat, (3) present a more uniform steel surface texture, (4) prevent fishscaling, (5) give a more uniform ground coat color, and (6) prevent rusting of ware in storage. The disadvantages of using a nickel dip are as follows: (1) it is always necessary to repickle a certain amount of ware whenever using a regular pickle set-up, and nickel-dipped ware is difficult to repickle; (2) the nickel dip is costly; and (3) close control of a nickel dip tank is necessary. Methods of controlling the nickel solution are enumerated. E.J.V.

Resistance to wear of enamel surfaces. R. ALDINGER. *Glashütte*, **68** [10] 184–86 (1938).—A. discusses various methods used to determine the resistance to wear of enameled surfaces. Resistance depends mainly on the composition of the enamel, on its working, and on the aftertreatment of the enameled ware. The determination of loss of surface luster is more suitable as a measure of the mechanical wear of enamel surfaces than the determination of the loss in weight, as the former detects the smallest wear of the surface while the latter yields usable values only after the enamel surface has undergone considerable wear. M.V.C.

Twenty-five determinations on cast iron in twenty-five minutes. FRANK J. OLIVER. *Iron Age*, **139** [20] 25–29

(1937).—The Campbell, Wyant, & Cannon Foundry Co., Muskegon, Mich., uses a spark spectrograph for determining silicon, manganese, chromium, nickel, copper, and molybdenum. Carbon, sulfur, and phosphorus are determined by chemical analysis. E.H.McC.

BULLETIN

Stannic Oxide as Opacifier in Wet Enamels. L. STUCKERT. *Internat. Tin Research Development Council Bull., Tech. Pub.*, **A65**, 81 pp. (1937).—S. investigated the influence of stannic oxide on impact resistance, thermal resistance, acid and alkaline extractibility, and opacification for 30 systematically varied enamels. Experiments were made on the rate of development of opacity, and a range of enamels was drawn up for the development of optimum opacification. The influence of particle size of stannic oxide on the opacification, luster, and acid and alkaline extractibility of an enamel was studied. A new impact-resistance tester was developed for determining the impact resistance of the enamel. The experiments show that the impact resistance of the enamel melts is improved by the addition of stannic oxide to the mill. In a majority of melts, this improvement corresponds with the increase of the added stannic oxide; in other cases a maximum effect of stannic oxide appears at about 6%. The addition of stannic oxide improves the thermal resistance of most enamels. Melts containing large amounts of fluorspar and cryolite are exceptions. The thermal resistance of many enamels rises continuously with increasing stannic oxide content, but in others a maximum is reached with about 6% stannic oxide. Addition of stannic oxide improves the acid resistance except in melts of abnormally high fluorine content. Addition of stannic oxide does not improve the resistance of the enamels to soda solutions. On alternate acid and alkaline extraction (lactic acid/ soda/ lactic acid), an improvement due to the stannic oxide is observed in acid extraction each time; the extraction by alkali remains unchanged. The presence of 9 to 11% of fluorides, fluorspar or cryolite, is most favorable for opacification by stannic oxide. Above this content the stability of the opacification toward firing suffers very considerably. The opacification of the enamel is also improved by a content of 8 to 10% of aluminum oxide, but the rate of development is retarded. Above a limiting value of about 13%, boric oxide detracts from the stannic oxide opacification. When enamels of high boric oxide content are fired, the surface luster sets in much earlier than maximum opacification. In almost all the enamels investigated, stannous oxide accelerates the development of opacity. Rapidity of production and firing stability of stannic oxide opacification are increased by a ratio of silicic acid : alkali = 50:15. High contents of alkali increase the opacity and reduce delay in its rate of production but lessen the stability toward firing. The most favorable fluorspar content is 6 to 9%; these enamels develop opacification completely with normal firing and are stable to firing. Higher contents cause a loss in opacity and luster on overfiring. With a cryolite content of about 12%, opacification develops simultaneously with optimum luster. The stannic oxide obtained by modern methods of manufacture is suitable from the point of view of its particle-size distribution.

C.B.JENNI

PATENTS

Baking pan set. J. G. JACKSON (Edward Katzinger Co.). U. S. 2,116,489, May 3, 1938 (Jan. 13, 1937; renewed March 3, 1938).

Centering pan set. J. G. JACKSON (Edward Katzinger Co.). U. S. 2,116,488, May 3, 1938 (Jan. 13, 1937). ARTHUR KATZINGER (Edward Katzinger Co.). U. S. 2,116,490, May 3, 1938 (Jan. 13, 1937).

Enameling machine. E. H. HARRIS (Wheeler Insulated Wire Co.). U. S. 20,712, May 3, 1938 (March 8, 1938); reissue of original U. S. 2,087,145, July 13, 1937.

Enamels. I. KREIDL. Fr. 817,310, Sept. 1, 1937; *Chem. Abs.*, **32**, 2310 (1938).—White enamels opacified by liberation of gas contain not less than 8%, preferably 8 to 12%, of F introduced as cryolite and for a normal content of boric acid are as free as possible from Al_2O_3. Examples are (1) borax 22, cryolite 18, Na_2CO_3 4, saltpeter 2, quartz 54%; (2) borax 14, cryolite 16, Na_2CO_3 4, saltpeter 3, quartz 43, and feldspar 20%; (3) borax 22, cryolite 12, Na fluosilicate 4, Na_2CO_3 4, saltpeter 3, quartz 40, and feldspar 15%.

Method and apparatus for removing enamel or similar glasslike material from metallic objects. H. B. MURDOCH AND B. B. KENT. Brit. 482,966, April 21, 1938 (Oct. 27, 1936).

Seamless baking pan set. J. G. JACKSON (Edward Katzinger Co.). U. S. 2,116,487, May 3, 1938 (Jan. 13, 1937).

Glass

Accomplishments of the industrial physicist in the glass industry. E. C. SULLIVAN. *Jour. Applied Physics*, **8**, 122–28 (1937).—In a glass factory the industrial physicist acts as a consultant in legal and manufacturing problems and has three specific functions: to watch product quality, to improve manufacturing methods, and to develop new products. A.P.

Alumina-silica relationship in glass. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **17** [5] 226 (1938).

American recommended practice of school lighting. ANON. *Trans. Illum. Eng. Soc.* [N.Y.], **33** [4] 321 (1938).—The American Recommended Practice of School Lighting is a revision of the Standards of School Lighting prepared under the joint sponsorship of the Illuminating Engineering Soc. and the American Inst. of Architects and adopted on Sept. 15, 1932, as an American Standard under the procedure of the American Standards Assn. In this new edition the primary purpose was to establish criteria of good illumination for the guidance of architects, engineers, school officials, and others interested in the conservation of children's vision and the efficiency of pupils and teachers. The information and recommendations presented may be of considerable use in the industrial lighting field. H.K.R.

Annual report on glass. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **17** [5] 226 (1938).

Blistery glass. LUDWIG SPRINGER. *Glashütte*, **67** [51] 785–86; [52] 798–800 (1937); **68** [6] 79–80 (1938).—The present classification of glass defects as bubbles, seeds,

gases, and dusty glass and according to size and shape is unsatisfactory. S. suggests the classification of these defects according to origin as follows: (1) bubbles due to defective melting: (*a*) true melting bubbles, (*b*) salt bubbles, (*c*) bubbles due to refractories, (*d*) so-called iron bubbles due to metallic oxides; (2) bubbles due to defective working: (*a*) air bubbles, (*b*) bubbles due to additional working, etc. Such a classification emphasizes the origin and aids in detecting these bubbles. M.V.C.

Chemical strength of glass in dependence on thermal treatment. O. S. MOLCHANOVA. *Optiko-Mekh. Prom.*, **7** [8] 3–5 (1937); abstracted in *Chem. Zentr.*, **1938, i,** 2427.—Three flint and three crown glasses (some cooled as usual, others chilled) were tested for their chemical resistance to the effect of a 0.5% CH_3COOH solution. The chilled glasses were less resistant than those cooled in the usual way. M.V.C.

Comment on Barrett and Taylor's method for studying the flow characteristics of glasses and slags at elevated temperatures. J. H. D. HEINE. *Jour. Amer. Ceram. Soc.*, **21** [6] 213–14 (1938). **Replies to discussion.** J. A. TAYLOR AND E. P. BARRETT. *Ibid.*, pp. 214–15; see *ibid.*, **19** [2] 39–44 (1936).

Comparison of tank furnaces adapted for Fourcault plants. M. G. STEPANENKO. *Keram. & Steklo*, **14** [1] 11–20; [2] 8–16 (1938).—This study is limited to tank furnaces used in the U.S.S.R. M.V.C.

Composition and properties of the chief types of commercial glasses. G. KEPPELER. *Jour. Soc. Glass Tech.*, **21** [88] 415–27 (1937).—The introduction of automatic machinery in bottle- and sheet-glass manufacture made unsuitable older glass compositions of high lime and low alkali content. Such glasses had high melting temperatures and great tendency to devitrify. When less lime and more alkali were used, the chemical durability decreased. The Mylius system of classifying chemical resistance and durability measurements by the powder method permit good predictions of the durabilities of soda-lime-silica glasses. The Mylius system, which is claimed to furnish the basis for the selection of inexpensive glasses of good durability, is described. See *Ceram. Abs.*, **6** [9] 378 (1927). C.J.P.

Cutting glass. M. W. JONES AND J. M. BLAIR. *Jour. Applied Physics*, **8**, 627–29 (1937).—Apparatus for applying a uniform cutting force and for studying breaking loads were developed and were used to investigate the effect of the length of the interval between marking and breaking on the torque required for breaking glass plates. Associated with a reduction in strain, the torque increased 30% in 16 days, mostly in the first 2 days. A load 50% less than that required for immediate breaking still broke the glass within 9 min. duration of loading. A correlation was found between the breaking load and the load on the marker. A.P.

Danish glassware. ANON. *Arts & Dec.*, **47** [4] 40–41 (1937).—Since 1825 glass has been made in the Holmegaard Glassworks. The sand, chalk, flint, and beech ashes are all found on the factory grounds. The present glass blowers are the descendents of those of the first Holmegaard plant. L.F.M.

Determining the chemical resistance of optical glasses by optical methods. N. V. SUIKOVSKAYA. *Optiko-Mekh. Prom.*, **7** [8] 12–16 (1937); abstracted in *Chem. Zentr.*, **1938, i,** 2427.—Measurements of the resistance of 20 glasses to the attack of a 0.5% CH_3COOH solution were made by determining the angle of elliptic polarization. S. found that increased temperature intensifies the attack. M.V.C.

Effect of pressure on the modulus of rigidity of several metals and glasses. F. BIRCH. *Jour. Applied Physics*, **8**, 129–33 (1937).—The effect of hydrostatic pressure on the modulus of rigidity has been determined to 4000 kg./cm.^{2} by a dynamical method. Absolute values of Young's modulus and the modulus of rigidity are given, and the derived compressibilities are compared with directly measured compressibilities. Five metals, Pyrex brand glass, and silica glass were studied. A.P.

Fluorescence of glass. P. GILARD, L. DUBRUL, F. JAMAR, AND D. CRESPIN. *Verre & Silicates Ind.*, **8** [35] 414–16 (1937).—Sodium silicates do not emit any rays, nor do soda glasses with lime, magnesia, baryta, zinc, and alumina; soda-lime glasses with Na_2SO_4, however, fluoresce. Potassium glasses with BaO and MgO have no fluorescence, but those containing lime, zinc, and alumina are fluorescent. Soda and potassium glasses containing PbO, melted in reducing conditions, emit yellow-pink and salmon colors, while those containing large amounts of nitrates emit a blue-violet fluorescence. Strong fluorescence was obtained with glasses containing B_2O_3 with K_2O or CaO and Na_2O or K_2O or with BaO and Na_2O. Secondary materials (non-coloring) are slightly active, and the effect of pigments is variable. Manganese glasses have a weak fluorescence. The effect of uranium, didymium, neodymium, and cerium is known. Gold-ruby and copper-ruby glasses generally do not fluoresce. Glasses containing S should be studied more extensively because the methods of the introduction of S are important for fluorescence. Selenium glasses fluoresce markedly. The color of fluorescence varies in Se and CdS glasses. Glasses containing silver have a white or yellowish characteristic fluorescence. M.V.C.

Formations of ultramarine in glassmelting furnaces. ANON. *Sprechsaal*, **71** [2] 33 (1938).—Deposits of intensive blue-green were found on the checker brick of a regenerative furnace. Analytical study showed the presence of ultramarine in a composition rich in silica. It is assumed that this formation is due to the presence of reducing gases and sulfur. M.V.C.

Fracture of glass plates by percussion. T. OKAYA AND K. ISHIGURO. *Proc. Phys.-Math. Soc. Japan*, **19**, 573–91 (1937); *Science Abs.*, **40** [477] No. 3885 (1937) (in French). Further results are given on the breaking of square glass plates by the impact of a needle point attached to a metal cylinder (*Ceram. Abs.*, **16** [8] 240 (1937)). Usually the break is a simple fracture of harmonic order N but sometimes combines two harmonics. The number of lines of fracture does not coincide with the order of the harmonic. The theory will be given in a subsequent paper. H.K.R.

Glass fibers. G. V. PAZSICZKY. Translated in *Glass Ind.*, **18**, 17–20 (1937); see "Preparation—," *Ceram. Abs.*, **16** [7] 202 (1937).

Glass: the trend of recent years. A. STAVENOW. *Times Trade & Eng.*, **42** [890] xlviii (1938).—Glass and pottery have shown rapid development in Sweden as a

result of the influence of artists in these industries. The most famous Swedish glass factories are those of Orrefors, Kosta, and Strömbergshyttan. At Orrefors, the coöperation between three leading artists and the most skilful glass blowers and engravers is particularly fortunate. This factory specializes in plain glass, engraved decorated glass (including "graal" glass used for expensive articles decorated with patterns in colored glass melted with the main body), tableware, and electrical fittings. The Kosta factory, founded in 1741, has specialized in tableware, especially cut glass. The Strömbergshyttan factory specializes in furnace-treated undecorated glass, but it also makes flat flute cut glass in tones of great beauty. A.B.S.

Heat transfer between the heated and unheated tanks of the furnace by gas streams. S. S. BERMAN. *Keram. & Steklo*, **14** [1] 21–25 (1938).—Mathematical computations of the amount of heat transferred by gas streams from the heated to the unheated tanks of continuously operating furnaces are given. M.V.C.

History of German and neighboring glass factories: II. H. KÜHNERT. *Glastech. Ber.*, **16** [3] 91–100 (1938).—99 references. For Part I see *Ceram. Abs.*, **17** [6] 216 (1938). J.F.H.

Hollow glass brick: their properties and uses in modern constructions. BERNARD LONG. *Verre & Silicates Ind.*, **9** [1] 1–5 (1938).—Methods of combining two half brick to obtain a hollow glass brick are discussed. The most advantageous method is that of lead welding at 200° after the brick have been hardened. The use of such brick as a building material is analyzed. M.V.C.

Illuminating properties of mat glasses. N. V. GORBACHEV AND E. S. RATNER. *Svetotekhnika*, **5**, 198–201 (1937); abstracted in *Chem. Zentr.*, **1938, i**, 2427.—Curves of light distribution show that mat glasses may be classified into three dispersion groups. The measure for dispersion capacity is the angle within which 70% of the light which penetrates the glass is transmitted. In glasses with poor dispersion, this angle amounts to 15°, in glasses with average dispersion it is from 15 to 30°, and in glasses with a high dispersion it is over 30°. M.V.C.

Insulation material. F. M. MCCLENAHAN. *Trans. Illinois State Acad. Sci.*, **29** [2] 215 (1936).—Material for use in insulating buildings and houses is prepared from lightly calcined silicic acid and formed by either extrusion or molding. The product has a heat transmission equivalent to that of prime cork. B.C.R.

Investigations to determine optimum conditions for the cutting off of hand-blown hollow glass. F. HOLLER. *Glastech. Ber.*, **16** [3] 85–90 (1938).—The tests were carried out on glass cylinders of 120 mm. diameter and 1.5 mm. wall thickness. The apparatus rotated the glass in a horizontal position, while heat was applied by small burners in a circular mounting. After proper heating, the samples were removed and scored with a moist diamond point. The quality of the cuts was rated numerically from 1 to 5 by visual examination (1 being perfect and 5 being unusable). The results are shown graphically by plotting quality against heating time. The curves show a maximum at the most suitable heating time. The maximum becomes sharper and is shifted to much shorter times by increasing the number of burners, and the quality is somewhat improved with quicker heating. The best heating time increases with increasing wall thickness with no effect on quality, and there is an increasing spread between underheating and overheating. With increasing radius of curvature, the most favorable heating time decreases somewhat. With glasses of the same coefficient of expansion (crystal, opal, flashed-opal glass) there was little distinction. With a borosilicate glass of lower expansion the optimum time was longer, showing a broader maximum. The best quality resulted with glass scored before heating, and the maximum was broader (less sensitivity to heating time). Insufficient heating results in completely smooth broken surfaces, while overheating causes a wavy shell-like surface. J.F.H.

Luminescence of glasses. E. REXER. *Glastech. Ber.*, **16** [3] 90–91 (1938).—A glass of the composition $Na_2Si_2O_5$ was examined in both the vitreous and crystalline conditions with and without an addition of 0.01% Cu. Excitation was brought about by Hg ultra-violet rays, cathode rays, and X-rays. Fluorescence observations showed little difference between the two vitreous forms or the two crystalline forms, but the difference between vitreous and crystalline materials was very distinct. Phosphorescence was noted only in crystalline materials excited by X-rays. The phenomenon may be useful as a criterion for crystallization. J.F.H.

Manufacture of optical glass at the Askania Works. FRANZ WARTE. *Verre & Silicates Ind.*, **9** [3] 30–33 (1938).—Methods used in the manufacture of optical glass and optical instruments are described. M.V.C.

Manufacture of sheet ruby glass. K. T. BONDAREV AND V. I. VANIN. *Keram. & Steklo*, **14** [2] 17–20 (1938).—A zinc borosilicate glass of the composition 68.5 SiO_2, 0.3 Al_2O_3, 0.1 Fe_2O_3, 6.3 B_2O_3, 0.3 CaO, 0.1 MgO, 11.0 ZnO, 12.0 NaO + K_2O, 0.8 CdS, 0.1 Se, and 0.5% SO_3 was used as a base. The glass was melted in a Siemens pot furnace. The color tone of ruby glass is influenced by (*a*) amount of pigments in the batch, (*b*) conditions of melting, (*c*) duration of melting at 1050° and 1100°C, and (*d*) time of annealing at temperatures below the softening temperature of the glass. Better results were obtained with concentrated Chasov-Yar sands because iron oxides affect the glass coloring. A second heating of the glass to the softening temperature diminishes the concentration of the ruby color; the glass becomes opalescent at higher temperatures. M.V.C.

Medieval glass in Holme-by-Newark Church, Notts. N. TRUMAN. *Jour. Brit. Soc. Glass-Painters*, **7**, 20–26 (1937); *Jour. Soc. Glass Tech.*, **21** [88] A436 (1937).—Further details are given. Illustrated. See *Ceram. Abs.*, **15** [5] 142 (1936).

Metallic molds for working glass. ANON. *Verre & Silicates Ind.*, **9** [8] 94 (1938).—Special steel alloys which have been used successfully for molding glass contain from 12 to 35% nickel and variable amounts of Cr, W, Si, etc.; they are heat resisting, have an austenitic structure, resist oxidation well, and possess a great durability. Experiments made in England with steel molds are discussed briefly. A French steel company has developed a special alloy for glass molds containing 60 Ni, 12 Cr, 2 W, and 0.5% Si and Fe. In some cases, molds made from this alloy permitted the production of two million bottles per

mold. The use of Monel metal for molds is discussed also. M.V.C.

Modern evolution of glassmaking. ANON. *Verre & Silicates Ind.*, **9** [8] 86–87; [9] 97–100 (1938).—The progress made in the 20th Century in the mechanization of the glass industry and the improvement of the physicochemical properties of glass and refractories used for glass-melting are described. M.V.C.

Reaction-rate theory of viscosity and some of its applications. RAYMOND H. EWELL. *Jour. Applied Physics*, **9**, 252–69 (1938).—E. applies the theory of chemical reaction rates to the viscosity and plasticity of condensed systems, including silicate glasses. A.P.

Spectrographic studies on ancient glass: Egyptian glass, mainly of the eighteenth dynasty, with special reference to its cobalt content. MARIE FARNSWORTH AND PATRICK D. RITCHIE. *Tech. Studies Field Fine Arts*, **6**, 155–73 (1938); *Chem. Abs.*, **32**, 2697 (1938).—Many fragments of Egyptian glass of the 18th and 19th Dynasties were examined spectrographically for Co, Ni, Mn, Pb, Cu, Sn, Sb, V, and Cr qualitatively and, to some extent, quantitatively in an attempt to account for the color. The results are tabulated. A list of references is included. See *Ceram. Abs.*, **17** [4] 139 (1938).

Stained glass. Introduction to its history and appreciation. C. NORRIS. *Jour. Brit. Soc. Glass-Painters*, **7**, 3–12 (1937); *Jour. Soc. Glass Tech.*, **21** [88] A436 (1937).—The history of stained glass lay between the years 1000 and 1500. Stained glass as a living craft having a technique of its own practically ceased about 1500. The history of colored windows after this date must be considered as that of a branch of painting, glass painters adopting at this time the naturalistic style, unsuitable as it was, of 16th Century Italian and Dutch masters. The 19th Century revival of the true craft and contemporary work will be considered later. The oldest existing stained glass windows are in the clerestory of Augsburg Cathedral. The most striking feature of 12th and 13th Century windows is the superb mastery of color, azure and ruby predominating.

Surface properties of fused salts and glasses: I, Sessile-drop method for determining surface tension and density of viscous liquids at high temperatures. II, Contact angle and work of adhesion on gold and platinum in various atmospheres. B. S. ELLEFSON AND N. W. TAYLOR. *Jour. Amer. Ceram. Soc.*, **21** [6] 193–213 (1938).

Various types of laboratory glasses. AURÉL BOGNÁR. *Magyar Chem. Folyóirat*, **43**, 145–48 (1937); *Chem. Abs.*, **32**, 3105 (1938).—The chemical composition of Pyrex brand, Nonsol, Ergon, Geräte 20, Resista, and Duran glasses is discussed. The Hungarian glass Ergon is shown to be of similar value to other laboratory glasses. Glassware can be evaluated on the basis of its resistance to alkaline solutions. Treatment with 0.1 *N* NaOH and 0.1 *N* Na_2CO_3 solution at 100° for 3 hr. dissolves about 0.1 g. glass on a surface of 1 sq. dm.

"Vitrail" (stained glass). E. E. VIOLLET-LE-DUC. *Jour. Brit. Soc. Glass-Painters*, **7**, 29–44 (1937); *Jour. Soc. Glass Tech.*, **21** [88] A436 (1937).—This is the first part of a translation by L. B. Holland from the French of a mid-19th Century work.

Walpole and his collection of stained glass at Strawberry Hill (near Twickenham). J. A. KNOWLES. *Jour. Brit. Soc. Glass-Painters*, **7**, 45–49 (1937); *Jour. Soc. Glass Tech.*, **21** [88] A436 (1937).—Horace Walpole, afterward Earl of Orford (1718–97), was a great collector of ancient painted glass. In 1842 the contents of his house at Strawberry Hill were sold. Particulars are given of some of the stained glass.

What can be detected from the chemical analysis of glasspots and what practical interpretations does it yield? FRITZ JOCHMAN. *Glashütte*, **68** [11] 215–16 (1938).—The results of chemical analysis of glasspots and refractory linings of tank furnaces may be used to determine what kind of glass may be melted in them; the calculation of the coefficient of expansion of the pots from the chemical analysis and its comparison with that of the glass will show whether they are suitable for melting definite types of glass. Examples are given. M.V.C.

BROCHURE

Brown-Firth Research Laboratories. ANON. Published by Thos. Firth and John Brown, Ltd., Sheffield, 1937. 71 pp. Free. Reviewed in *Jour. Soc. Glass Tech.*, **21** [88] A442 (1937).—This excellently illustrated brochure gives a clear picture of the operation and work of the laboratories. About half of the book consists of lists of publications from the laboratories, books, reprints, and periodicals contained in the reference library attached to the laboratories.

PATENTS

Acoustical material. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 2,114,546, April 19, 1938 (Feb. 7, 1936).

Air-tight joints between metals and ceramic materials. GENERAL ELECTRIC CO., LTD. (Patent Treuhand-Ges. für elektrische Glühlampen). Brit. 483,565, May 4, 1938 (Oct. 19, 1936).

Apparatus for:

Cutting glass flowing from the glassmaking furnace into plates. L. D. ZAĬKO. Russ. 44,646, Oct. 31, 1935; *Chem. Abs.*, **32**, 3111 (1938).—Construction details are given.

Making multicellular glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 818,606, Sept. 30, 1937; *Chem. Abs.*, **32**, 2702 (1938).

Making sheet glass. W. G. KOUPAL AND H. F. HITNER (Pittsburgh Plate Glass Co.). U. S. 2,114,715, April 19, 1938 (Jan. 11, 1936).

Making sheets of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 820,400, Nov. 9, 1937; *Chem. Abs.*, **32**, 3111 (1938).

Manufacture of colored glass. PIERRE BROSSÉ (Soc. Anon. Holbrever). U. S. 2,115,408, April 26, 1938 (June 19, 1934).

Supporting glass sheets. R. S. HINSEY (Libbey-Owens-Ford Glass Co.). U. S. 2,115,106, April 26, 1938 (March 20, 1936).

Chamber for drawing glass tubes and rods. S. I. KOROLEV. Russ. 44,645, Oct. 31, 1935; *Chem. Abs.*, **32**, 3111 (1938).—Construction details are given.

Colored glass plates. Balog Ferenc és Társa Fal- és Padlóburkoló Vállalat and István Forgó. Hung. 117,241, Nov. 15, 1937; *Chem. Abs.*, **32**, 3112 (1938).—A film is cemented on the colored surface and it is covered (1) with a lacquer layer to protect it against mechanical effects, and (2) with a waterproof layer consisting of asphalt, bitumen, or resinous varnish containing montan wax, and (3) with a layer insoluble in water and oils, *e.g.*, shellac.

Decorative treatment for laminated structures and product thereof. L. V. Casto. U. S. 2,115,409, April 26, 1938 (Oct. 21, 1935). A decorative glass sandwich comprises a substantially transparent glass panel having an open design image thereon on one side.

Draft control for leers. J. A. Sweeney and C. C. Rau (Fairmount Glass Works, Inc.). U. S. 2,115,594, April 26, 1938 (March 22, 1937).

Drawing double-walled windowpanes. George Aurien. U. S. 2,116,297, May 3, 1938 (June 17, 1937).

Equipment for drawing double-layer glass in a horizontal direction. S. I. Korolev. Russ. 44,647, Oct. 31, 1935; *Chem. Abs.*, **32**, 3111 (1938).—Construction details are given.

Forming necks on bottles, etc. Vereinigte Lausitzer Glaswerke A.-G. Ger. 649,733, Aug. 19, 1937 (May 14, 1936); V 32,807, VI/32*a*, Gp. 26; *Jour. Soc. Glass Tech.*, **21** [88] A398 (1937).—In a method of forming conical necks on bottles and other glass vessels, using a holder for the bottle capable of rotation and longitudinal displacement with a plug movable on the same axis with a set of rollers, the rollers are so disposed with respect to the plug that they are capable of movement perpendicular to the axis of the bottle holder.

Glass. Kodak (Australasia) Pty., Ltd. Australian 101,886, Sept. 2, 1937; *Chem. Abs.*, **32**, 2702 (1938).—An optical glass of high refractive index contains less than 25% SiO_2 and more than 20% of oxides of Ti, Y, Zr, Cb, La, Hf, Ta, W, or Th.

Glass article shaping machine. A. F. Tremblay (Kent-Owens Machine Co.). U. S. 2,115,051, April 26, 1938 (March 9, 1935).

Glass batch. F. C. Flint (Hazel-Atlas Glass Co.). U. S. 2,116,623, May 10, 1938 (Feb. 19, 1936). The method of preparing glass batches for clear transparent glass includes first determining the amount of carbon naturally present in the batch as dirt, dust, etc., and then adding carbon in an amount sufficient to bring the total carbon to the percentage desired.

Glass fabric road. Carleton Ellis (Ellis Laboratories, Inc.). U. S. 2,115,667, April 26, 1938 (Jan. 9, 1937). An asphalt road contains as the flexible bonding agent a vitreous siliceous composition consisting of glass fibers present in the form of fabric.

Glass feeder. B. D. Brown (Capstan Glass Co.). Can. 373,212, April 19, 1938 (June 22, 1936; in U. S., Dec. 28, 1935). G.M.H.

Glass furnace. Corhart Refractories Co. Fr. 818,571, Sept. 29, 1937; *Chem. Abs.*, **32**, 2702 (1938).—Construction of a basin bottom is described.

Glassmelting furnace. J. E. McBurney (Owens-Illinois Glass Co.). U. S. 2,114,744, April 19, 1938 (April 3, 1936).

Glass press. H. W. Arnold and Charles Badger (Lamb Glass Co.). U. S. 2,116,921, May 10, 1938 (Aug. 26, 1935).

Glass tile or panel. Joseph Labra. U. S. 2,114,473, April 19, 1938 (April 30, 1936).

Guide and deflector for glass charges. J. W. Ross (Hazel-Atlas Glass Co.). U. S. 2,116,284, May 3, 1938 (Dec. 10, 1936).

Hardening glass. Fritz Eckert. Ger. 653,769, Dec. 2, 1937; Cl. 32*a*. 30; *Chem. Abs.*, **32**, 3112 (1938).

Heat-insulating material. Vlastimil Straka, Bernard Weiner, and Jindrich Kloubek. Fr. 819,738, Oct. 26, 1937; *Chem. Abs.*, **32**, 3053 (1938).—Ground glass is mixed with substances which vaporize at the vitrification temperature without decomposing, *e.g.*, Zn, thus forming air spaces in the vitrified mass. Sinking of the mass during cooling is prevented by adding substances which act chemically on one another, causing a strong liberation of heat, *e.g.*, a mixture of Fe_2O_3 and Al.

Heat- and sound-insulating bodies of spun glass. O. Gossler Glasgespinst-Fabrik Ges. Brit. 482,809, April 21, 1938 (Dec. 11, 1936).

Laminated article. B. C. Bren (E. I. du Pont de Nemours & Co.). U. S. 2,115,514, April 26, 1938 (Nov. 7, 1935). Laminated glass comprises a sheet of glass and, bonded thereto, a plastic sheet comprising 100 parts of cellulose acetate having an acetyl number of 51 to 54.5 and 80 to 100 parts of dimethyl phthalate as a plasticizer therefor.

Lens for photography, etc. H. W. Lee (Kapella, Ltd.). U. S. 2,117,252, May 10, 1938 (Dec. 17, 1936).

Load-bearing glazed building block. Albert Henderson (W. P. Witherow). U. S. 2,115,264, April 26, 1938 (Feb. 13, 1937). A wall composed of successive courses of blocks, each having spaced side walls and vertical voids therebetween, window openings in the side walls and window lights in the openings whereby a ray of light may pass through a window of one block, partially through the voids of the one block and a block in an adjacent course, and then through a window of the last-mentioned block.

Luminous glass letter sign. Bartlett Vandermeer (Flexlume Corp.). U. S. 2,114,550, April 19, 1938 (Feb. 4, 1937).

Making porous filter bodies of particles of glass. Paul Prausnitz (Jenaer Glaswerk Schott & Gen.). U. S. 2,114,748, April 19, 1938 (May 2, 1935).

Making a thermal insulating unit. E. R. Powell (Johns-Manville Corp.). U. S. 2,114,353, April 19, 1938 (April 17, 1934). A method of making an insulating unit comprises converting molten material into mineral wool fibers, uniformly mixing with the hot fibers a binding or skeletonizing material which is a solid at normal temperatures, felting the fibers and material into a coherent pad, shaping the pad, applying slight uniformly distributed pressure to the pad, and confining the warm pad before the binder solidifies in a stiff form-retaining casing.

Manufacture of sheet glass. F. L. Bishop (American Window Glass Co.). U. S. 2,116,693, May 10, 1938 (Sept. 8, 1934).

Manufacturing light-diffusing glass articles. Österreichische Glasfabriken und Raffinerien J. Inwald Akt.-Ges. Brit. 482,399, April 13, 1938 (Jan. 9, 1937).

Means for manufacturing molded glassware. P. V. W. GELL (British Heat Resisting Glass Co., Ltd.). U. S. 2,115,765, May 3, 1938 (Feb. 12, 1936).

Melting and refining of glass, etc. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 482,532, April 13, 1938 (Dec. 28, 1935).

Mineral wool composition. H. T. COSS (Johns-Manville Corp.). U. S. 2,116,303, May 3, 1938 (Nov. 28, 1934). A mineral wool comprises silica, alumina, alkaline-earth metal oxide, and sodium oxide, the proportion of silica being 8 to 10 times that of the alumina, the proportion of alkaline-earth metal oxide being larger than that of the sodium oxide, and the proportion of sodium oxide being 5 to 11 parts to 100 parts of the mineral wool.

Objects made of nonporous silica. JOHN A. HEANY. Fr. 819,710, Oct. 26, 1937; *Chem. Abs.*, **32**, 3113 (1938).—Objects of high mechanical resistance and high density are made by molding to the desired shape finely divided activated siliceous material vitrifying rapidly and easily and heating to below the melting point of SiO_2. The siliceous material may be obtained by decomposition of $SiHCl_3$, SiH_4, Si_2H_6, $Si(OEt)_4$, $SiMe_4$, and $SiEt_4$.

Paddles for operating in the forehearths of glass furnaces. F. W. ARMYTAGE. Brit. 482,615, April 13, 1938 (Dec. 2, 1936).

Process and apparatus for producing mineral wool. L. W. CHANTLER (Standard Lime and Stone Co.). U. S. 2,112,557, March 29, 1938 (Nov. 6, 1935).

Producing designs, patterns, or ornamental effects on molded ware. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND G. KING. Brit. 482,395, April 13, 1938 (Jan. 1, 1937).

Production of double-walled illuminating globes. VEREINIGTE LAUSITZER GLASWERKE A.-G. Ger. 647,751, June 24, 1937 (Feb. 4, 1936); V 32,527, VI/32*a*, Gp. 8; *Jour. Soc. Glass Tech.*, **21** [88] A433 (1937).—The two portions are blown in a closed mold, and a tool acting only on the center is used to press one half down toward the other.

Production of glass brick. OWENS-ILLINOIS GLASS CO. Ger. 649,620, Aug. 19, 1937 (March 10, 1936); O 22,302, VI/32*a*, Gp. 24_{04}; *Jour. Soc. Glass Tech.*, **21** [88] A384 (1937).—In a process, *e.g.*, for making glass building block in which two or more portions are united to give an enclosed space at subatmospheric pressure, a metallic substance having a chemical affinity for glass and a melting temperature above the annealing temperature of the glass is sprayed onto the edges or surfaces to be united while they are still hot, after which the two halves are brought together and annealed in the ordinary way.

Production of quartz plates pierced with holes. BERLINER QUARZ-SCHMELZE G.M.B.H. Ger. 648,487, July 15, 1937 (April 20, 1936); B 173,855, VI/32*a*, Gp. 35; *Jour. Soc. Glass Tech.*, **21** [88] A385–86 (1937).—Holes are produced in plates of fused quartz, or other material fusible with difficulty, by a grinding process.

Production of screw mouth double-walled vessels. J. DICHTER. Ger. 647,205, June 10, 1937 (Dec. 24, 1932); D 64,946, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [88] A400 (1937).—In forming double-walled vessels by fusing together the edges of an inner and outer portion, means are provided for pressing a threaded plug of the required configuration into the mouth opening.

Protective glass. FRANZ WEIDERT AND HANS LÖFFLER (Degea Aktiengesellschaft). Can. 373,217, April 19, 1938 (May 21, 1937). G.M.H.

Reducing the tendency of tempered glass articles to yield under their internal stresses. R. HADDAN (Corning Glass Works). Brit. 482,914, April 21, 1938 (Dec. 24, 1936).

Removing iron oxides from the glass melt. I. I. KITAIGORODSKIĬ AND L. B. ZISSERSON. Russ. 44,318, Sept. 30, 1935; *Chem. Abs.*, **32**, 3111 (1938).—Fe oxides are removed by introducing into the melt NaCl and KNO_3.

Safety glass and process for manufacture. SOC. DES USINES CHIMIQUES RHÔNE-POULENC. Brit. 483,143, April 27, 1938 (Dec. 17, 1936).

Severing and reuniting glass objects. L. C. STRINGER (Light Service Corp.). U. S. 2,116,129, May 3, 1938 (Dec. 3, 1935).

Shearing charges of molten glass fed to semiautomatic machines. HALLESCHE PFÄNNERSCHAFT ABT. DER MAUSFELD A.-G. FÜR BERGBAU UND HÜTTENBETRIEB. Ger. 647,440, June 17, 1937 (Oct. 22, 1934); H 141,587, VI/32*a*, Gp. 15; *Jour. Soc. Glass Tech.*, **21** [88] A392 (1937).—Shear blades are placed between the top of the parison mold and the guide funnel and are operated by a handle.

Sintering glass batch. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 2,114,545, April 19, 1938 (Aug. 17, 1935).

Spraying booth for applying decoration. LEIPZIGER TANGIER-WERK A.-G. Ger. 649,266, Aug. 5, 1937 (April 17, 1935); L 87,930, XII/75*a*, Gp. 22; *Jour. Soc. Glass Tech.*, **21** [88] A413 (1937).—In a spray booth for applying decoration from a paint gun in known fashion, the sides, bottom, and draw-off cone are protected by jets of air under pressure issuing from nozzles suitably disposed along a main surrounding the top of the booth. A "curtain" of moving air also protects the front of the booth.

Table decorating unit. W. L. ORME. U. S. 2,115,962, May 3, 1938 (April 23, 1937).

Temperature control for molten streams. H. K. RICHARDSON AND F. A. NEWCOMBE (Westinghouse Electric & Mfg. Co.). U. S. 2,116,450, May 3, 1938 (Dec. 28, 1934). An apparatus for controlling the temperature of a stream of molten glass comprises a container for the glass, means for heating the glass to a molten condition, an orifice of uniform area through which the glass flows continuously in the form of a stream, and means for regulating the heating means to maintain the stream at a constant temperature.

Uniting quartz and metal pieces. "OSA" PARTICIPATIONS INDUSTRIELLES, SOC. ANON. Fr. 819,071, Oct. 9, 1937; *Chem. Abs.*, **32**, 2704 (1938).—A quartz piece is coated with a powdered refractory metal, *e.g.*, W, and a metal piece is then secured by soldering or welding. Methods of procedure are indicated.

Wall construction. J. E. BAUER (Owens-Illinois Glass Co.). U. S. 2,115,513, April 26, 1938 (June 23, 1936). A wall structure comprises courses of blocks having glazed surfaces and a bonding medium uniting the blocks and having an average tensile strength of approximately 27 lb./sq. in. in the direction of its length and height, the bonding medium including titanic oxide enamel and grit.

Structural Clay Products

Adobe house construction. VIRGINIA FINCKE. *Arts & Dec.*, **47** [2] 26–28, 46 (1937).—The problems that confronted F. in joining and remodeling two old adobe houses are given. This type of construction is very satisfactory and inexpensive. The brick are 8 in. x 16 in. up to 11 in. x 19 in. and weigh from 40 lb. up. Interiors are finished in plaster. Illustrated. L.F.M.

Adobe houses in southern California. ELOISE ROORBACH. *Arts & Dec.*, **46** [4] 28–30, 43 (1937).—Many modern adobe houses are patterned after the century-old adobes of San Diego County. Several outstanding examples are discussed with reference to brick size, wall thickness, white wash, and tile covering. Illustrated. L.F.M.

Chimneys of Old Spain and England. KATHARINE MORRISON KAHLE. *Arts & Dec.*, **48** [1] 19, 40 (1938).—The chimney, as we know it, made its début in the fifteenth century. The development from that time to the present state of perfection is given. Illustrated. L.F.M.

Efflorescences in ceramic materials. R. LEDUC. *Rev. Matériaux Construction Trav. Publics*, No. 338, p. 170B (1937).—Effective methods to prevent efflorescences in ceramic products are (1) intensive firing, (2) careful selection of suitable clay, and (3) additions of $BaCO_3$. M.V.C.

Flaws in brick. O. KALLAUNER. *Stavivo*, **1937**, p. 113.—The chief requirements are shape, color, density, waterproof quality, resistance to frost, strength, and the absence of harmful substances. R.B.

Further study of water penetrability of clay and shale building brick. J. W. MCBURNEY AND A. R. EBERLE. *Bull. Amer. Ceram. Soc.*, **17** [5] 210–16 (1938).

Properties of brick products. JOSEF MATĚJKA. *Stavivo*, **1937**, p. 165.—M. discusses published literature on the dimensions, permeability, resistance to frost, strength under pressure, formation of efflorescence, the properties of border brick (especially the influence of porosity on the formation of efflorescence), brick used for building smokestacks, their resistance to acid, roofing tile, ducts, and fired roofing. R.B.

STANDARD

Standards for testing and supplying solid brick. ANON. Issued by decree of the Ministry of Public Works, Dec. 23, 1931, No. 10-532/92–86,325 ai 1931. State Printing Office, Prague, 1933.—The differentiation comprises the following classes:

	Average max. permeability (%)	Individual permeability (%)	Min. strength in pressure (kg.)
Stoneware brick	7.5	9	600
Hard or sharply fired brick	15.0	18	300
Strong brick	15 or more	15 or more	150
Ordinary brick	15 or more	15 or more	75

Regulations are prescribed concerning (1) kind, (2) external appearance, (3) internal composition (including the matter of efflorescence), (4) dimensions (29 x 14 x 6.5 cm.) and maximum tolerance (length 3%, width 4%, thickness 5%), (5) permeability, (6) resistance to frost (−10 to −15° and 15 to 20°C, 25 tests), and (7) strength under pressure, determined on small test cubes (5 x 5 x 5 cm.) cut out from the central and outer parts of the brick (5 tests). R.B.

PATENTS

Building block. F. O. ANDEREGG (Owens-Illinois Glass Co.). U. S. 2,114,732, April 19, 1938 (Aug. 8, 1933; renewed Oct. 4, 1937). A rectangular building block comprises top, bottom, and end surfaces designed to be embedded in mortar when the block is built into a wall, an outer or front exposed surface, the entire top, bottom, and end surfaces consisting of beads or corrugations extending parallel with the outer face of the block, the corrugations being of sufficient fineness to insure a good bond between the block and mortar and to substantially prevent the passage or creeping of moisture across the corrugated surfaces, and a coating of material on the corrugated surfaces which will permit mortar to adhere thereto.

Building block. L. S. FOWLER. U. S. 2,115,160, April 26, 1938 (Aug. 13, 1937).

Building construction. P. A. WOOD. U. S. 2,116,859, May 10, 1938 (Aug. 12, 1937). In a building construction, a foundation wall having its upper edge formed with upper and lower shelf portions connected by an outwardly inclined draining wall, outer and inner masonry wall sections laid in spaced relation on the upper and lower shelf portions, weep holes provided between the outer wall and the lower shelf portion of the foundation wall, and tie elements connecting the outer and inner wall sections.

Connecter for drain tile. J. C. ULLMAN. U. S. 2,116,-165, May 3, 1938 (June 1, 1937).

Hollow brick. A. ŠVARC. Czechoslovak P2570–35. Dimensions of the brick are 22 x 14 x 14 cm. Perpendicular to the flat surface are 24 small hollows. The brick are joined to each other by a groove and spring. R.B.

Sanding attachment for brickmaking machines. H. L. CAMPBELL. U. S. 2,115,301, April 26, 1938 (June 9, 1936).

Ventilating building block. J. H. WHITMARSH. U. S. 2,116,457, May 3, 1938 (Aug. 23, 1937). A building construction of the class described comprises a foundation wall, floor joists supported on the wall, a flooring overlying the joists, a cementitious ventilating building block supported on the foundation wall in the plane of the joists, a veneering of brick, etc., supported on the ventilating block, and a screened ventilating opening in the block for establishing a circulation of air from the outside of the building and between the floor joists.

Refractories

Action of carbon monoxide on refractory materials: III, Experiments with laboratory-prepared specimens. W. HUGILL, H. ELLERTON, AND A. T. GREEN. Reprinted in *Trans. Ceram. Soc.*, **37** [1] 6–11 (1938); see *Ceram. Abs.*, **12** [6] 228 (1933). **IV, Deposition of carbon on certain ferruginous substances.** *Bull. Brit. Refrac. Research Assn.*, No. 31 (June, 1933); reprinted in *Trans. Ceram. Soc.*, **37** [1] 12–16 (1938).—Hematite, magnetite, pyrites, and an iron oxide-clay fusion were subjected to a series of five heat treatments. With the raw materials, comparatively small depositions of carbon were noted. Hematite induces the greatest deposition. Hematite fired to 500°, 800°, or 1200°C induces pronounced deposition in the first 5 hr. With magnetite fired to 500°, 900°, and 1200°C, the deposition during the latter 15 hr. is appreciably greater than with hematite. For Parts **I–II** see *Ceram. Abs.*, **13** [10] 261 (1934). R.A.H.

Attempts to produce fused mullite. A. S. GINSBERG. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **1**, 585–601 (1936); abstracted in *Chem. Zentr.*, **1938, i**, 1639.—Attempts to manufacture fused mullite from Chasov-Yar clay, kyanite, andalusite, bauxite, and corundum in a high-frequency furnace are described. Experiments with Chasov-Yar clay and kyanite or white bauxite as raw materials were successful. M.V.C.

Effect of highly refractory additions to sagger mixes. R. MAKHL. *Keram. & Steklo*, **14** [2] 27–31 (1938).—Ceramic and physicomechanical studies showed that (1) the introduction of silicon carbide into sagger mixes greatly improves their properties; such saggers have high thermal resistance and sufficient mechanical strength; (2) additions of corundum have a less marked effect, although they also improve the properties of saggers; and (3) admixtures of kyanite or andalusite have no marked effect on the properties of saggers. The fact that low-grade kyanite and andalusite were used, however, must be considered. See "Quantitative—," *Ceram. Abs.*, **17** [5] 187 (1938). M.V.C.

Electrically fused magnesia. H. E. WHITE. *Jour. Amer. Ceram. Soc.*, **21** [6] 216–29 (1938).

Ferrochrome slag in refractories. TERESCHENKO. *Zitein-Tech. So.*, Series 27, 1239, 4 pp. (1937); abstracted in *Referat. Silikatliteratur*, **5** [2] 4902 (1938).—Large quantities of slag are formed during the manufacture of ferrochrome. Its composition is given. The use of pure slags as a refractory material is unsatisfactory because of their high content (14 to 17%) of calcium silicates, anorthite, and diopside and because their refractoriness amounts to only 1430° or 1470°C. Additions of magnesite, chromite, and sulfite liquor to the slags improved them greatly. Brick made of mixes containing 30% slag, 20 to 40% magnesite, and 30 to 50% chromite and fired to 1450° showed the following characteristics: refractoriness, 1920°; incipient softening under pressure, 1450°; resistance to temperature variations (49 chillings); cold resistance to pressure, 500 kg./sq. cm.; water absorption, 40.4%; porosity, 28.72%; specific gravity, 2.52. M.V.C.

Hydraulic bond in refractory masonry. *Ciment fondu.* MARCEL LÉPINGLE. *Verre & Silicates Ind.*, **8** [34] 403–407; [35] 416–18; [36] 425–28 (1937).—The principal advantages of *ciment fondu* are as follows: (1) it hardens rapidly and its mechanical resistance is very high 24 hr. after setting; (2) it is stable under load up to 1300°, and with a chromite or chrome magnesia aggregate it can be used up to 1600°; (3) refractories of lower grade may be used with *ciment fondu*, and it does not require prefiring as do refractories with a clay bond; (4) it has no marked shrinkage; (5) it resists variations of temperature without spalling; (6) its thermal conductivity is somewhat lower than that of refractories used with it; and (7) it may be molded into any shape without danger of deformation or cracking. See "Cements—," *Ceram. Abs.*, **15** [6] 180 (1936). M.V.C.

Manufacture of graphite crucibles. F. AUGUSTIN. *Stavivo*, **1937**, p. 175.—Fifty years ago the porcelain factory of Kiovský and Trinks in Smichov, Praha, endeavored to manufacture this ware, but the actual manufacture was begun by A. in Czechoslovakia in 1927 in the Platinon factory at Třemosná near Plzen. The material used consists of 48 to 55% Ceylon and Madagascar graphite in the form of flakes, 30 to 36% very plastic fireproof Klingenberg loam from Bavaria, and about 15% of other minerals and sharpening material such as kaolin, Rakovnik chamotte, granular sand, broken pieces of crucibles, and sometimes corundum and feldspar. These raw materials are mixed and kneeded in a mixing machine for about 2 hr.; then on a small press, a cylinder 10 to 12 cm. in diameter and about 12 cm. in length is drawn from the mass. These cylinders are flattened by hand into plates which are put one upon another in the form of a large cone, sprinkled with graphite powder, and placed into plaster of Paris molds. The latter are turned on a small potter's wheel by means of a fixed pattern, and crucibles of the contents from 100 to 200 kg. are drawn in this manner by hand. The drawn crucibles are removed from the mold by a special device, placed on wooden slabs, allowed to set, and then smoothed out and retouched. They are completely dried and fired in a muffle furnace with a capacity of 10 to 12 m.³ at pyrometric cone 013. 6 illustrations. R.B.

Monolithic furnace construction. JOHN DUGUID. *Jour. Record Trans. Junior Inst. Engrs.*, **47**, 101 (1936–37).—D. discusses the usual difficulties of firebrick construction due to bulging of walls, the main points of weakness being the joints and the attachment of the fire brick to the supporting structure. An ideal furnace refractory for monolithic linings should have (1) low drying shrinkage, (2) great bonding strength, (3) ability to be molded to any shape desired, (4) low contraction under load, (5) ability to withstand temperatures up to 3000°F, and (6) high resistance to spalling. The advantages of this material in the construction of boilers and other furnaces are discussed. The chemical composition is 54.0 SiO_2, 38.0 Al_2O_3, 1.5 Fe_2O_3, 2.2 TiO_2, 0.1 alkalis, 0.6 CaO + MgO, and 4.0% ignition loss. The use of a refractory concrete, installed in the same manner as ordinary concrete, is described. D. recommends this material for use in furnaces operating below 2700°F. B.C.R.

Notes on refractories. RAYMOND E. BIRCH. *Brit. Clayworker*, **46** [550] 441–42 (March, 1938). R.A.H.

Petrographic methods applied to the study of silica brick. V. L. BOSAZZA. *Trans. Ceram. Soc.*, **37** [1] 1–5 (1938).—B. describes the procedure used in preparing samples of silica brick for examination and the microscopic and petrographic examination of these thin sections. R.A.H.

Protection of the blast-furnace wall. YOSHIHIKO HIRAKAWA. *Suiyokwai-Shi*, **9**, 425–34 (1938); *Chem. Abs.*, **32**, 2881 (1938).—The erosion of the wall of an iron blast furnace by impact and rubbing action of charge, deposition of carbon, softening under load, and corrosion by slag, flame or gases, and heat is discussed. Large, heavy cast-iron protectors should be used as the throat lining in place of smaller castings, and the outside of the throat should be coated with steel plates. The wall of the shaft should be lined thinly at the upper half and thickly at the lower half and surrounded by a steel-plate shell in place of cooling box or pipe. The boshes should be cooled by cooling boxes and enclosed in steel plates or bands. The furnace bottom should be protected by steel plates and cooled by water from the outside. The space between the steel plates and the brickwork retort should be packed with granulated carbon.

Refractories for enameling furnaces. JOHN WALKER. *Chem. Age* [London], **34**, 290–91 (1936).—Enameling muffles and muffle furnaces consist of (1) a heat-generating chamber, (2) the working space, and (3) a general structure surrounding 1 and 2. For the combustion chambers, brick with a refractoriness of cone 34 to 35 is recommended, but fused alumina ware (which has a high volume stability) is needed for the high temperatures in some oil-fired furnaces. The use of aluminous brick avoids the risk of sudden collapse which may occur with silica brick. The highly resistant "white lime" or bleached interface between aluminous brick and slag coatings is important. Silicon carbide brick is recommended where clinkering occurs and subsequent stripping leads to mechanical damage. Fused alumina and silicon carbide panel brick for the muffle shell are economical because of the high thermal conductivity of these materials, but silicon carbide is liable to oxidation, growth, and distortion under strongly oxidizing conditions between 800° and 1000°C. The use of high-temperature insulating brick leads to rapid heating and a saving in fuel. See *Ceram. Abs.*, **16** [4] 119 (1937). A.B.S.

Refractoriness of silicoaluminous products. H. LONGCHAMBON. *Céramique*, **41** [600] 47–52 (1938).—L. discusses the method of interpreting the determination of softening temperatures under load at high temperatures. There are numerous interpretations with respect to incipient softening, true softening, sagging, and rapid softening. The determination of the resistance to pressure at increasing temperatures until the actual softening occurs is important. These determinations are very delicate. If the data submitted by laboratories is considered, silicoaluminous products seem to be incapable of rendering service as refractories. The temperature of incipient softening of these products is about 1000°, and their true softening is 1100° to 1200° according to the method used; rapid softening occurs at about 1500°, while the fusing cone temperature reaches 1700°. The important temperature is that at which the rate of sagging becomes important, *viz.*, the rapid sagging temperature. The phenomenon of sagging under load is not a simple one; indications are that there is no difference between sagging and shrinkage. L. separated these two variables by repeatedly firing samples until the shrinkage factor was entirely eliminated. In the case of a raw sample, a curve is obtained whose slope starts at 800° and reaches its asymptote at 1500°, while for products whose shrinkage was eliminated, the curve practically resumes its course at two perpendicular places whose vertical abruptly starts at 1500°. These tests were confirmed by traction tests by which the value and importance of shrinkage were emphasized. The curve thus determined includes first a phase of expansion, then a phase of shrinkage, and at 1500° the appearance of viscosity; this exactly closes the cycle, and shows that the only temperature important for the engineer is that at which the rate of sagging becomes considerable. In masonry the effect of shrinkage is not so important, as only a small part of the total construction reaches the dangerous temperature, but viscosity presents a real danger, and as soon as its temperature is exceeded the masonry runs. M.V.C.

Refractory products and mortars; observations and formulas. E. G. *Argile*, No. 178 (Feb.), pp. 17–19 (1938).—The majority of difficulties encountered in furnaces are due to inferior characteristics of mortars and not to the refractory brick. The use of a mortar of the same composition as the brick is recommended. This is possible with grog brick and grog mortar, but it is difficult to obtain the same results with silica brick containing 95% SiO_2. Mortar having the same composition but of sufficient plasticity is difficult to produce, since the crystalline material reaches a proportion of 90%. The use of pulverized silica brick with a low alumina content is recommended to prevent a rapid expansion with increase in temperature. Experiments with a ball clay-type mortar of the composition 89.7 silica, 6.4 alumina, 1.1 iron oxide, 1.8 lime, and 1% residue were successful. The alumina content may be lowered when pulverized brick containing less than 3% Al_2O_3 is used. An American refractory and insulating product, Zonolite, is briefly discussed. M.V.C.

Reliability of thermal conductivity measurements for insulating materials. H. OLIVER. *Trans. Ceram. Soc.*, **37** [2] 49–59 (1938). **Discussion.** A. H. JAY, *et al. Ibid.*, pp. 59–61; see *Ceram. Abs.*, **17** [5] 188 (1938). R.A.H.

Sikarbid. O. KALLAUNER. *Stavivo*, **1937**, p. 261.—The Commission for the standardization of refractory building materials of the Czechoslovak Normalization Society, coöperating with the Czechoslovak Ceramic Society, encountered difficulties in denoting refractory ware made of silicon carbide. The name Carborundum, although freely used, is protected by the United Works for the Manufacture of Carborundum and Electrite and by Czechoslovak patents Nos. 15,633, 16,657, 20,256, 22,826, and 20,847; therefore the ware is called Sikarbid. R.B.

Silica brick. I. S. SMELYANSKIĬ, L. V. DRAZHNIKOVA, AND YA. GUT. *Zitein-Tech. So.*, Series 27, No. 1270, 6 pp.

(1937); abstracted in *Referat. Silikatliteratur*, **5** [2] 4906 (1938).—Attempts to improve the properties of silica brick for open-hearth furnaces (because the melting point of silica brick lies near the working temperature of these furnaces) are described. Quartz powder with water and molasses was used as a bond for the brick. Properties of the brick are as follows: refractoriness, 1750° to 1760°; beginning of softening under pressure, 1650° or 1670°; specific gravity, 2.40; porosity, 16.5 to 18.7%; expansion on heating, 3%; cold resistance to pressure, 480 to 585 kg./sq. cm.; and after-expansion on heating to 1450°, 0.4 to 0.7%. The microstructure showed 33 to 63 tridymite, 20 to 45 cristobalite, and 12 to 15% quartz. M.V.C.

Unified testing of refractory building materials. O. KALLAUNER. *Stavivo*, **1937**, p. 34.—K. gives a detailed account of this proposal. R.B.

Walling-up boilers and chambers for firing with coal dust. JAROSLAV DOSKOČIL. *Stavivo*, **1937**, p. 22.—Refractory brick with 7 to 13% permeability, at least 37% Al_2O_3, and a resistance of at least 34 pyrometric cones are the most satisfactory. Their load-bearing capacity at 2 kg./cm.² is as follows: beginning of softening at 1136° to 1290°C; fast softening at 1344° to 1580°C; change of volume after 2 hr. firing at 1500°C, 0.71 to 3.27%; good resistance to sudden cooling and chemical influences. 2 illustrations. R.B.

BULLETIN

Refractory mortars; coating and ramming materials for the foundry. L. C. HEWITT. *Amer. Refrac. Inst. Tech. Bull.*, No. 68, 6 pp. (1938).—The success of an installation of refractory material often depends upon the bonding material used and the way in which it is applied. The product should possess the following properties: (1) necessary plasticity to permit proper application, (2) sufficient refractoriness to withstand the prevailing temperatures, (3) reasonable resistance to subjected slag or chemical action, (4) bonding qualities at the furnace temperatures, (5) resistance to thermal shock where necessary, and (6) lack of shrinkage in use, except when it is used as an expansion joint material. For the proper use of refractory materials, the following precautions must be observed: (*a*) reasonable and necessary care should be taken in the mixing, soaking, etc., of the material; (*b*) all precautions in the application which the results warrant should be employed; (*c*) water content must be kept to the minimum necessary for the particular application; the higher the water content, the longer will be the period required for drying out; (*d*) sufficient time should be allowed for drying before high temperatures are applied; steam, rapidly formed in a plastic lining or patch, will, by its explosive effect, cause the material to loosen from its place; (*e*) in winter, the product should be warmed sufficiently before use to remove any frost present. H.E.S.

PATENTS

Alumina. F. N. STROKOV, V. A. MUSYAKOV, V. S. VOLKOV, E. YA. ITKINA, R. I. MELAMED, AND R. V. PROKOF'EVA. Russ. 44,245, Sept. 30, 1935; *Chem. Abs.*, **32**, 3102 (1938).—Al silicate-containing material is fused with 1.3 to 1.7 mols. lime per mol. of Al_2O_3 at a $CaO:SiO_2$ ratio of 1.4. The product is leached with Na_2CO_3 solution.

Furnace lining. H. H. BLAU AND H. N. BAUMANN, JR. (Carborundum Co.). Can. 373,109, April 12, 1938 (April 9, 1935); see *Ceram. Abs.*, **15** [8] 245 (1936). G.M.H.

Porous refractory articles. IVAR SETTERBERG. Ger. 654,369, Dec. 18, 1937; Cl. 80*b*. 18.02; *Chem. Abs.*, **32**, 2704 (1938). See Swed. 87,709 (*Ceram. Abs.*, **16** [10] 305 (1937)).

Refractory brick. ERIC RICHARDSON. Fr. 818,665, Oct. 1, 1937; *Chem. Abs.*, **32**, 2704 (1938). See Brit. 471,373, Sept. 15, 1937.

Refractory material. P. P. BUDNIKOV AND D. A. NIRENSHTEIN. Russ. 44,828, Oct. 31, 1935; *Chem. Abs.*, **32**, 3114 (1938).—Comminuted raw dolomite containing 5 to 8% SiO_2 is mixed with about 15% chrome iron ore, fired, and ground to be used directly or for lining furnaces, etc., or for refractory brick with or without firing.

Refractory material. CARBORUNDUM CO. Ger. 653,705, Dec. 1, 1937; Cl. 80*b*. 817; *Chem. Abs.*, **32**, 3114 (1938).—Masses for fireproof, abrasive, and other uses are obtained by allowing a fused mixture of oxides of Al, Cr, Mg, Si, and Fe, containing over 50% of Al_2O_3 in solid solution with chromite, under 10% MgO, and under 5% SiO_2, to solidify. The mixture may be made up from Cr spinel with Al_2O_3 in solid solution and Fe_2O_3.

Terra Cotta

Ceramic facing tile. KAREL HINEIS. *Stavivo*, **1937**, p. 59.—According to the Czechoslovak standard ČSN 2010–1931, facing tile always means glazed porous tile. Besides this, however, terra cotta, stoneware tile made of common or fine stoneware material, majolica, or porcelain tile may be designated as facing tile. R.B.

Ceramic tile of the Swiss industry. HALLER. *Argile*, No. 179, pp. 9–13 (1938).—H. gives the results of a series of tests with tile manufactured in Switzerland carried out at the Federal Laboratory for Testing Materials of the Zurich Institute of Research. M.V.C.

Experiences in the manufacture of faience ware and garden ceramics. J. LIEBSCHER. *Stavivo*, **1937**, p. 141. R.B.

Flaws in the structure of roofing tile. FRANTISEK NĚMĚCEK. *Stavivo*, **1937**, p. 23.—These flaws are prevented or diminished by placing a knife in the cylinder and by dividing the snail into several parts, separated from one another by a suitably arranged ring 5 to 7 cm. wide. In other cases the parts of the snail are shortened, and the shortened part moves back about 20° so as not to be directly in the way of the forward moving paste or to cut it. Another flaw in roofing tile is the occurrence of so-called "hairs." These appear especially on the products not sufficiently dry or when the product is suddenly steamed when being dried in the kiln. This occurs with the smooth thin tile that have been pressed hard. R.B.

Importance of Vinohrady Ceramic School for manu-

facture of glazed tile products. LADISLAV FEJTEK. *Stavivo*, **1937**, p. 56. R.B.

Manufacture of pressed roof tile. F. ONDRUŠ. *Stavivo*, **1937**, p. 64. R.B.

Use of porcelain pipes for hot-spring piping. G. C. KORNMESSER. *Gas- & Wasserfach*, **81** [8] 126–29 (1938).—A line of porcelain tubes 1.5 km. in length for conducting the water from a hot spring proved satisfactory. K. describes the methods of laying and protecting the pipes and making joints. M.H.

STANDARDS AND BOOK

Method for Testing Chemical Stoneware. British Standard Specification No. 784—1938. BRITISH STANDARDS INST., London. The following properties were tested: (*1*) *Tensile strength:* A test piece of special shape, gripped by special jaws, is subjected to a tensile force increasing uniformly at a rate not exceeding 100 lb./12 sec. The tensile strength is usually 900 to 1500 lb./sq. in. (*2*) *Compressive strength:* The test piece, preferably of 1 in. side, is crushed under a steadily increasing pressure. The usual compressing strength is 45,000 to 75,000 lb./sq. in. (*3*) *Transverse strength:* A bar, 8 in. x $^1/_2$ in. x $^1/_2$ in., is placed on knife-edges 6 in. apart and the load is applied through a centrally placed knife-edge. The modulus of rupture is calculated by the usual formula; the transverse strength is usually 4000 to 5600 lb./sq. in. (*4*) *Resistance to impact:* A pendulum impact machine is used. The test piece is an unnotched cylinder, 6 in. long and 0.5, 0.75, or 1.25 in. in diameter. The usual value obtained is 1.5 kg./sq. cm. (*5*) *Resistance to abrasion:* A weighed slab, 4 in. square, is subjected to a sandblast using air at a pressure of 50 lb./sq. in. and applied for 2 min. It is then reweighed and the loss is expressed as a percentage of the original weight. The apparatus is shown diagrammatically. The abrasive consists of (*a*) sand, of which 68% passes through a B.S.I. 25-mesh sieve and is retained on a 36-mesh and 32% passes through a 36-mesh sieve and is retained on a 52-mesh; and (*b*) steel shot, of which 15% passes through a B.S.I. 10-mesh sieve and is retained on a 16-mesh, and 85% passes through a 16-mesh sieve and is retained on a 25-mesh. (*6*) *True (powder) density:* Density is determined in the usual manner but the following steps are specified: (*a*) the material is ground so as to pass through a B.S.I. 200-mesh sieve and is dried at 110°C to constant weight; (*b*) a 25 or 50 ml. density bottle is used, the liquid being paraffin (kerosene, flash point not below 126°F); (*c*) the bottle with contents should be evacuated with a filter pump for 15 min.; and (*d*) air is then admitted and the bottle again evacuated for 15 min. The true density of chemical stoneware is usually 2.45 to 2.55. (*7*) *Apparent density:* A test piece weighing about 200 g. is dried at 110°C, weighed, immersed in paraffin, and evacuated with a filter pump overnight. It is then weighed suspended in paraffin. The superfluous paraffin is removed from the surface, and the test piece is weighed suspended in air. The apparent density is usually 2.1 to 2.4. (*8*) *Porosity:* The porosity due to open pores into which paraffin can penetrate is calculated from the data obtained in determining the apparent density. It is usually 6 to 18%. (*9*) *Water absorption:* Any glaze is removed by grinding, and the dried test piece is immersed in cold water which is raised to the boiling point and kept boiling for 1 hr. The weight of water absorbed is usually 0 to 3%. (*10*) *Specific heat:* The calorimeter and steam heater are shown diagrammatically. The sample, broken into small pieces, is heated until it has a temperature of 100°C, and then transferred to a known weight of water at a known temperature in a calorimeter, and the rise in the temperature of the water is noted. The specific heat, calculated by the usual formula, is usually 0.18 to 0.19 for a temperature range of 17° to 100°C. (*11*) *Thermal expansion:* The test piece, 4 in. long and less than 1 in. in diameter, is placed in a tube of fused silica which it fits closely. A dial gage and thrust rod is fitted, and the tube is partly immersed in a furnace or oil bath and heated to the requisite temperature. The expansion shown by the dial added to the corresponding expansion of the fused silica is the absolute expansion of the test piece. Thermal expansion is usually 4 to 5 $\times$ 10^{-6}. The temperature range of chief interest is 0° to 150°C. (*12*) *Thermal conductivity:* Two methods, a cube method and a slab method, are described with the necessary calculations and illustrations. They can not be abstracted. No figure for stoneware is given. (*13*) *Acid-soluble iron:* The sample is ground to pass a B.S.I. 60-mesh sieve and be retained on a 120-mesh sieve, and a weighed quantity is boiled in 20% hydrochloric acid and filtered. Any copper present is separated by adding mercuric chloride, passing H_2S, and filtering. The excess of H_2S is then removed and the iron determined calorimetrically with ammonium thiocyanate. (*14*) *Acid solubility and chemical resistance:* A crushed sample (25 g.) free from glaze is immersed in a mixture of 25 g. concentrated sulfuric acid (1.84), 10 g. concentrated nitric acid (1.42), and 65 g. of water and heated until the sulfuric acid begins to fume. The heating is repeated after adding a little dilute nitric acid. After cooling, the sample is washed with a good stream of water dried, and reweighed. The usual loss of weight is less than 0.5%. (*15*) *Resistance to thermal change:* There is no satisfactory method for the direct determination of this property, but it can be calculated (for a range of 80°C) from the thermal expansion and the progressive amount of deflection (measured vertically) which takes place when making the transverse test, using a given formula. This method is suitable only for stoneware of the same type, made from the same (or very similar) clays. A.B.S.

Fired Roofing: Vol. 3. JOSEF MATĚJKA. 758 pp., 295 illustrations, 1937. Chapter headings are as follows: (1) raw materials: (*a*) characteristics, (*b*) selection; (2) mining and preparation of the raw materials: (*a*) opening the clay pit, (*b*) extracting the raw materials, (*c*) estimation of a clay pit, (*d*) preparation of raw materials; (3) transportation of raw materials; (4) manufacture: (*a*) by hand, (*b*) by machinery; (5) drying: (*a*) conveyance of raw tile, (*b*) kilns, (*c*) firing, (*d*) firing control; (6) addenda to the manufacture of fired roofing: (*a*) driving machinery, (*b*) firing of tile, (*c*) sorting, (*d*) calculation of production cost; (7) (*a*) history, (*b*) kinds of tile, (*c*) properties and testing of tile, (*d*) flaws in tile; and (8) roofs: (*a*) placing of roofing, (*b*) characteristics of roofing made of fired tile. R.B.

Standards for testing and supplying fired tile. ANON. Issued by decree of the Ministry of Public Works, Oct.

10, 1927, No. 10-17/48-53,326. State Printing Office, Prague, 1927. Regulations are prescribed concerning (1) kind, (2) external characteristics, (3) dimensions, (4) weight, (5) impermeability under exposure to artificial rain, (6) bearing capacity in bending, (7) composition and appearance of the fracture, and (8) resistance to frost. R.B.

PATENTS

Flashing brick or tile. GEORGE FINK. U. S. 2,115,067, April 26, 1938 (April 1, 1937).

Semiresilient ceramic tile flooring section. JOSEPH LABRA. U. S. 2,114,474, April 19, 1938 (Nov. 14, 1936).

Whiteware

Effect of glazes containing CaO on the shrinkage of porcelain. G. L. EFREMOV AND V. M. KRASNYANSKAYA. *Keram. & Steklo*, **14** [2] 24–27 (1938).—It was found that a glaze with an increased marble content (partially replacing feldspar) penetrates into the body of the ware on firing and greatly hampers the shrinkage of porcelain; in thin-walled bodies, shrinkage diminishes 5 to 6%. This change in shrinkage in the surface layers of the body introduces deformation, cracking, and other defects. Mineralogical investigation showed that this phenomenon may be accounted for by new mineralogical formations which produce local volume changes. A detailed petrographic and physicochemical study should be made of this phenomenon, which is of great practical and theoretical interest. M.V.C.

Manufacture and suitability of porcelain cables. HANS ZIEGLER. *Rundschau Deut. Tech.*, **18** [6] 7–8 (1938); *Chem. Abs.*, **32**, 3107 (1938).—Since August, 1937, when the first hard porcelain cable (both covering and insulation) was made entirely from German raw materials, many such semistiff cables have been laid underground, one of them 4 km. in length. The single insulating pipes, only 1.5 to 2.0 m. long, are connected by links. The links are as waterproof, chemically resistant, and electrically and mechanically suitable as the porcelain pipes, without being entirely stiff. Early in 1938, an improved connecting joint was perfected. Experiments with such joints laid in salt water for over 13 months under an a.-c. voltage of 5000 v. showed no change in their electrical properties. This new kind of porcelain cable can be used at permanent temperatures up to 90°.

Technical progress of the Czechoslovak porcelain industry since 1927. GUSTAV KOPKA. Read before Congress of the Czechoslovak Ceramic Society, May 23, 1937; *Stavivo*, **1937**, p. 259. R.B.

Use of talc and pyrophyllite in semivitreous dinnerware bodies. E. H. LINTZ. *Jour. Amer. Ceram. Soc.*, **21** [6] 229–37 (1938).

PATENTS

Compositions for making spark plugs. ROBERT BOSCH A.-G. Ger. 655,082, Jan. 7, 1938; Cl. 80*b*. 8.03; *Chem. Abs.*, **32**, 2704 (1938).—In the manufacture of spark plugs by firing a mixture of corundum and a ceramic binder, use is made of a binder which, after it has been fired, becomes slightly plastic over the approximate temperature range 500° to 800°. A specified binder is made from a mixture containing talc 32.7, kaolin 43.3, and feldspar 24%. A method of testing ceramic binders to determine their suitability for use in the process is described.

Flush bowl. D. W. MCNEIL (John Douglas Co.). U. S. 2,116,527, May 10, 1938 (Dec. 7, 1934).

Pothead. T. F. BRANDT (Ohio Brass Co.). U. S. 2,117,696, May 17, 1938 (Sept. 28, 1935). U. S. 2,117,697, May 17, 1938 (Jan. 30, 1936).

Sanitary basin, etc. ADOLF EHRHARDT (Triton Belco A.-G.). U. S. 2,116,015, May 3, 1938 (Dec. 1, 1936).

Sanitary lavatory. C. M. ALLEN. U. S. 2,116,133, May 3, 1938 (July 24, 1937).

Saucers for supporting cups, glasses, etc. A. C. GIBSON. Brit. 482,778, April 21, 1938 (March 6, 1937).

Spark plug insulator. T. G. MCDOUGAL, A. H. FESSLER, AND KARL SCHWARTZWALDER (General Motors Corp). Can. 372,937 and 372,938, April 5, 1938 (May 7, 1937). G.M.H.

Equipment and Apparatus

Continuous investigation of fibrous or fine-grained materials in the through-flow chamber. K. TROTT. *Chem. App.*, **25** [6] 91–92 (1938).—T. describes an arrangement by which the material to be investigated is carried in a continuous flow through a small flat chamber under a microscope. The chamber has glass walls for observation with the microscope and for illuminating the material. M.H.

Difficulties in drying. VLADISLAV ULMAN. *Stavivo*, **1937**, p. 154.—The brick most difficult to dry are the "hourdis" brick; some drying plants even reserve special places for them. When the heat and air circulation is well controlled, however, they may be dried thoroughly in any plant. R.B.

Driers for roofing tile. T. A. GOSKAR. *Trans. Ceram. Soc.*, **37** [2] 62–71 (1938). **Discussion.** H. H. MACEY, *et al.* *Ibid.*, pp. 71–73; see *Ceram. Abs.*, **17** [5] 193 (1938). R.A.H.

Drying equipment for liquid and pasty masses. TROCKNUNGS-ANLEGEN-GESELLSCHAFT M.B.H. *Eng. Progress*, **19** [3] 60 (1938).—Two electrically heated cylinders rotate in opposite directions with the material to be dried fed down between them. The distance between cylinders is adjustable to the nature of the material. The dry material is removed from the cylinders by scrapers. Drying temperature can be adjusted as desired. J.L.G.

Drying plant classification. JOSEF MATĚJKA. *Stavivo*, **1937**, p. 153.—Artificial drying plants may have the following sources of heat: (1) kiln heat: (*a*) that radiated by the kiln itself, (*b*) smoke gases, and (*c*) heat furnished through the cooling of individual chambers; (2) heat from steam-driven machinery: (*a*) from the ex-

haust steam, (*b*) sharp heat, and (*c*) from the smoke gases of the boiler room; and (3) heat developed directly in the drying plant. Drying plants may be classified according to whether they are open, chamber, or tunnel drying plants, with natural or artificial draft on the pressure or suction principle, whether air circulation is simple or manifold, with added heat or without it, etc. M. describes the chief chamber drying plants of Bührer, Keller, Geiger, Dannenberg, and Pösner, those with manifold air circulation (tunnel drying plants), such as Möler-Pfeiffer's and Matějka's, and those using the vacuum principle. See *ibid.*, **1926**, p. 343; "Natural drying shed" this page. R.B.

Industrial machinery. Modern mineral grinding plant. ANON. *Made in India* (Supp. to *Indian Eng.*), pp. 46–48 (Dec., 1937).—Some efficient grinding machines and pulverizers, *e.g.*, Hardinge Mill, Raymond Automatic Pulverizer, I. C. Grinder, and Lopulso Mill, are described. A.P.S.

Maintenance and repairs of grinding machinery. W. A. STAPLETON. *Chem. Age* [London], **34**, 143–45 (1936).—A full investigation as to the probable cost of repairs should be made before purchasing the machinery. The machinery should also be chosen for its work if excessive maintenance cost is to be avoided, *e.g.*, a slow-moving mill may take 10% more power, but this is more than balanced by excessive abrasion in fast-running mills. Proper selection of the grinding media (balls) in ball mills is important. Access needed before making repairs often makes the cost of repairs excessive; quick access to the interior of machinery tends to reduce cost of maintenance and repairs. Crushing rolls of chrome steel last longer than those of chilled iron. The same is true of the ring in ring-grinding mills. The effect of a rise in temperature on the lubricant may be important. It is a mistake to run a plant until a general overhaul is needed; each part should be put in good condition as soon as possible and so maintained. A.B.S.

Natural drying sheds. JOSEF PÖSNER. *Stavivo*, **1937**, p. 109. R.B.

New tables of psychrometric properties of air-vapor mixtures. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **10** [2] 119–22 (1938).—The derivation and use of the new psychrometric tables are further explained (*Ceram. Abs.*, **17** [6] 226 (1938)). G. discusses and gives numerical examples of (1) approximate methods of computing the heat to be removed, (2) computation of absolute humidity, (3) specific volume of dry air and of air-vapor mixtures, and (4) humid specific heat. J.L.G.

Polarized light enters the world of everyday life. MARTIN GRABAU. *Jour. Applied Physics*, **9**, 215–25 (1938).—The recent development of an inexpensive optical polarizing material is greatly extending the field of applied optics. G. classifies and describes applications of the new sheeting. A.P.

Road haulage for brickmakers. RICHARD TWELVETREES. *Brit. Clayworker*, **46** [550] 430–34 (March, 1938).—Vehicles and operating methods for hauling brick are discussed. R.A.H.

Utilization of high temperatures and high pressures produced by the detonation of explosives in the artificial reproduction of minerals: zincite and willemite. A. MICHEL-LEVY AND J. WYART. *Compt. Rend.*, **206** [4] 261–63 (1938).—By bringing a highly explosive substance into contact with mineral substances in the steel explosion bomb ZnO and Zn_2SiO_4 were produced. The temperatures developed in the bomb rose to 3000° to 4000°C for 3 to 4 × $1/10^6$ of a second. The procedure is described in detail. M.H.

BULLETINS

Ball-Mill Grinding. WILL H. COGHILL AND FRED D. DEVANEY. *U. S. Bur. Mines Tech. Paper*, No. 581, 56 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 15¢. Facts based on experiments supplement old literature on fine grinding; these facts are a foundation upon which to erect theories. The work of previous investigators is discussed. Experimental evidence on important points in fine grinding is dealt with, and a study is made of innovations in fine grinding. The tests described show that successive changes in set and induced variables in ball milling produce traceable and orderly changes in the products. R.A.H.

Control of dust from blasting by a spray of water mist. CARLTON E. BROWN AND H. H. SCHRENK. *U. S. Bur. Mines Repts. Investigations*, No. 3388, 13 pp. Free. A test is described which determines the effectiveness of spraying blasted material with water mist, commonly called compressed-air blast or water blast, to reduce the concentration of dust in air after blasting and during mucking. R.A.H.

Dust sampling with the Bureau of Mines midget impinger, using a new hand-operated pump. J. B. LITTLEFIELD AND H. H. SCHRENK. *U. S. Bur. Mines Repts. Investigations*, No. 3387, 4 pp. Free. The authors describe a new hand-operated pump for operating the midget dust-sampling impinger recently developed by the Bureau of Mines and its operation. A comparison of the results obtained with the midget and regular impingers is given. See *Ceram. Abs.*, **17** [5] 194 (1938). R.A.H.

Primary crushing: Progress report No. 1. MARK SHEPPARD AND C. N. WITHEROW. *U. S. Bur. Mines Repts. Investigations*, No. 3377, 11 pp. **Progress report No. 2.** MARK SHEPPARD. *Ibid.*, No. 3380, 16 pp. Free. These are the first of a series of reports discussing the various phases of primary crushing, such as the relation between size gradations of feed to and product from primary crushers, the particle shape of the crushed product, and differences in gradation and particle shape produced by various crushers and by crushing different kinds of stone. R.A.H.

Technique for routine use of the konimeter. J. B. LITTLEFIELD, C. E. BROWN, AND H. H. SCHRENK. *U. S. Bur. Mines Information Circ.*, No. 6993, 6 pp. Free. The circular-type konimeter and its preparation for use are described. The collection of dust samples, counting the samples, and the calculation of dust concentration are also discussed. R.A.H.

Willson products for industrial safety. WILLSON PRODUCTS, INC., Reading, Pa., 1938. 34 pp. Free. This well-illustrated catalog covers eye, nose, throat, and lung protectors, and includes more than fifty types of goggles for every purpose, twelve welding handshields

and helmets, seven U. S. Bureau of Mines approved types of dust respirators, air-line respirators, abrasive helmets, etc.

PATENTS

Air dust removing apparatus. HERMANNUS VAN TONGEREN (Buell Combustion Co., Ltd.). Can. 372,915, April 5, 1938 (June 18, 1936). G.M.H.

Apparatus for automatically delivering predetermined quantities of pulverulent or granular substance or material. STANLEY EATON. U. S. 2,116,105, May 3, 1938 (Sept. 9, 1937).

Apparatus for de-airing clay, etc. J. M. WILLIS AND C. L. WILLIS. Brit. 482,968, April 21, 1938 (Nov. 6, 1936).

Cloths for filter presses. J. S. HEATH AND C. R. HEATH (trading as G. H. Heath & Son). Brit. 482,612, April 13, 1938 (Nov. 28, 1936).

Electric smelting furnace cover. PAUL HONEGGER (Sulzer Frères, Soc. Anon.). U. S. 2,116,202, May 3, 1938 (Feb. 13, 1936).

Lining for ball mills. J. C. RUMBARGER AND R. S. SCHWENDLER (Enamel Products Co.). U. S. 2,114,640, April 19, 1938 (July 3, 1935).

Machine for and method of decorating ware. W. M. SECOY (Solar Laboratories). U. S. 2,116,466, May 3, 1938 (March 15, 1935).

Machine for stenciling ware. W. M. SECOY (Solar Laboratories). U. S. 2,116,467, May 3, 1938 (Aug. 22, 1935; renewed Aug. 10, 1937).

Sand mulling machine. W. H. NICHOLLS, SR. (National Engineering Co.). U. S. 2,117,977, May 17, 1938 (June 9, 1937).

Sintering mineral substances and porous product thereof. E. I. LINDMAN. U. S. 2,116,030, May 3, 1938 (Aug. 21, 1936).

Stenciling apparatus. W. R. SIMONTON (Owens-Illinois Glass Co.). U. S. 2,114,323, April 19, 1938 (Aug. 25, 1936).

Kilns, Furnaces, Fuels, and Combustion

Design and firing of kilns: II–III. ANON. *Brit. Clayworker*, **46** [550] 422–25 (March, 1938); **47** [552] 4–6 (1938).—A discussion of the design and operation of the beehive and rectangular downdraft kilns is presented. For Part I see *Ceram. Abs.*, **17** [5] 195 (1938). R.A.H.

Determination of the specific heat of gases at high temperatures by the sound-velocity method: II, Carbon dioxide. G. G. SHERRATT AND E. GRIFFITHS. *Proc. Roy. Soc.* [London], **A156**, 504–17 (1936).—The specific heat values for carbon dioxide obtained by the sound-velocity method are as follows:

Temp. (°C)	C_v cal./g./mol. at 1 atm.	Temp. (°C)	C_v cal./g./mol. at 1 atm.
0	6.62	600	10.81
200	8.65	800	11.30
400	10.06	1000	11.76

A.P.

Excess air in combustion of fuel in annular kilns. JOSEF PÖSNER. *Stavivo*, **1937**, p. 194.—No great improvement has been made in annular kilns. P. presents a systematic study of firing in an annular kiln. For a given kiln and firing temperature, the excess of air is practically invariable and does not admit any changes possible in other firing boxes. P. expresses this by the equation

$$n = \frac{700}{Cv\,/\,tp - tv + \Delta tp + \Delta tv}\left\{1 - \frac{Czm_1}{W}(tp - tz)\right\},$$

where W = the calorimetric value of the fuel at n times excess of air, tz = heat to which the ware is brought in the heating, tv = the temperature of ware at the end of the cooling belt, Δtv = the drop in temperature at this point, tp = the firing temperature, Δtp = the further drop in temperature, m = the mass of ware in kg. which is heated by 1 kg. of the fuel from the temperature tz to the temperature tp, Cv = the specific heat of the air, and Cz = the specific heat of the ware mass. Although, as far as excess of air during firing is concerned, deviations may occur, nevertheless, the excess of air can not be utilized to effect calorific saving for it can not be changed at will without detrimental results to the firing. R.B.

Fuels of today and tomorrow. A. C. FIELDNER. *Combustion*, **9** [2] 35–38 (1937).—The total energy supplied from mineral fuels in the U. S. increased from 14,000 trillion B.t.u. in 1907 to 24,600 trillion in 1929; after a depression drop, the figure in 1936 was raised to 21,800 trillion B.t.u. Industry and public utility power consumed 45%, transportation about a third, and domestic and miscellaneous uses one-fourth of the energy supply. In 1929, coal constituted 84% of the fuel for domestic and miscellaneous purposes, 73% of that for industrial use and public utility power, and 57% of that for transportation; petroleum provided 43% of transportation fuel, including almost 100% of road-vehicle and airplane fuel, 73% of marine fuel, and 11% of railroad fuel. Natural gas comprised 16% of industrial and public utility power consumption and 7% of domestic and miscellaneous consumption. Since 1929, 7% of the total energy demanded has been transferred from anthracite and bituminous coal to petroleum, natural gas, and water power. H.E.S.

Heat transfer—counterflow *versus* parallel flow. J. H. SENGSTAKEN. *Combustion*, **9** [1] 16–20 (1937).—S. presents a complete set of curves showing the exact relation between counterflow and parallel flow of heat. Plotting them in this manner not only simplifies their use and application but also gives a graphic representation of what heat recovery can and can not be accomplished economically for almost any set of conditions. H.E.S.

Industrial gas-burner systems. RAYMOND F. MANN. *Amer. Gas Jour.*, **148**, 13 (March, 1938).—M. discusses various types of burner systems and burners, listing the manufacturers of each. See *Ceram. Abs.*, **17** [6] 227 (1938). B.C.R.

Influence of draft on combustion. BEDŘICH HELAN. *Stavivo*, **1937**, p. 57.—The difference in draft which would be evolved by the smokestack at the moment when smoke gases stand still corresponds to the so-called static stage

and is called static draft. It increases in a direct ratio with the height of the smokestack, the heat of the gases within the smokestack, and the coolness of the outside air. It serves not only in giving velocity to smokestack gases but also in compensating draft losses in the smokestack and the grate. The loss in draft may be occasioned by the change in direction, the friction of gases against the walls, the upward pressure in the sinking parts of the canals in passing through the layer of fuel on the grate (grate resistance), etc. Both the smokestack and the draft canals must have correct and proper dimensions. R.B.

Kiln construction. F. KANDEŘÁBEK. *Sborník na počest průmyslníka F. Slavíka (Almanac in Honor of F. Slavík)*, **1936,** p. 34.—In the construction of the new tile factory at Žihle near Podbořany, attempts were made to provide the kiln with the most nearly even and most perfectly controlled temperature. For this purpose a Zig-Zag kiln proved satisfactory. The grates were made of walled-in chamotte brick in such a way as to make it possible for one grate to fire four rows of tile and to cause the rise of temperature on them to be very gradual. To bring about an even distribution of the air circulating through the chambers of the kiln, special brakes made of chamotte plates were made, which direct the air toward the front walls, the space between the wall and the first row of products being 40 cm. Since the smoke circulates through the smoke canal with considerable velocity, care was taken to make the walls as tight as possible and the obstacles to circulation as small as possible. This was achieved by increasing the cross-section of the smoke-collecting canal to 1.9 m.²; thus, the draft canals were conducted by the shortest route and with the fewest necessary deviations in direction as possible, by increasing the valves to 700 mm. in diameter, by making all changes in direction of the canals in slight arches, and by walling-up the walls of the canals to make them smooth. 5 illustrations. R.B.

Necessity of drying a new kiln before firing it. JOSEF STODOLA. *Stavivo*, **1937,** p. 220.—The ware must be set in the kiln in such a way as to enable the steam from the walls to run directly to the smokestack and not into the brick. Kotwalt recommends a special way of achieving this. R.B.

Reduction of iron oxides by carbon monoxide in the presence of natural impurities. F. OLMER. *Compt. Rend.*, **206** [5] 353–55 (1938).—The disintegration $2CO \rightarrow CO_2 + C$ is fairly weak except when a catalyzer is present, especially pure oxides, when the following reaction takes place: $3CO + Fe_2O_3 \rightarrow Fe_2 + 3CO_2$. If, however, anhydrous phosphoric acid or anhydrous aluminates are present, the catalytic action is seriously impeded if not entirely suppressed. M.H.

Roman pottery kiln at Lincoln. F. T. BAKER. *Lincolnshire Mag.;* reprinted in *Brit. Clayworker*, **47** [552] 22–24 (1938).—B. describes a loaded and fired pottery kiln unearthed in 1936 in the grounds of the Technical College, Lincoln. R.A.H.

Should the downdraft periodic kiln be round or rectangular? W. D. RICHARDSON. *Bull. Amer. Ceram. Soc.*, **17** [5] 197–200 (1938).

Stoker-fired round downdraft kilns. J. H. ISENHOUR. *Bull. Amer. Ceram. Soc.*, **17** [5] 201–202 (1938).

Thermotechnical notes on the firing of brick products in the annular kiln. BEDŘICH HELAN. *Stavivo*, **1937,** p. 112.—The decisive factor in the consumption of coal in brick firing in annular furnaces is the chimney loss and the loss due to heat radiation through the walls, armature, and flooring of the kiln. The chimney loss in kilns well tended and stacked with well-dried products is about 8 to 15%, while the temperature of the smoke gases is about 100°C. If the products being fired are damp, the loss amounts to 25 to 30%. The radiation loss for the inside surface of the kiln amounts to 200 to 300 k.-cal./m.²/hr. If the kiln walls are thick enough, the radiation loss is limited to the vaulting of the kiln, and the main loss constitutes the heat consumed in the heating and cooling of the kiln. This brings up the importance of insulation on the inner side of the kiln. The Czechoslovak refractory industry manufactures special well-tested products for this purpose. R.B.

Use of electrical heating in firing ceramic tile. ANON. *Nord Industriel*, p. 16 (Jan., 1938); abstracted in *Verre & Silicates Ind.*, **9** [8] 92 (1938).—The use of electric furnaces in ceramics resulted in economies in labor and raw materials and in shortening the duration of firing. Round and tunnel kilns fired with coal or fuel oil have a low thermal efficiency (about 4% for round kilns), and the ware must be protected during firing by either saggers or muffles. The normal firing temperature of these kilns is about 1400°C. In electric furnaces, the firing is done by direct radiation of the resistors at a temperature between 1250° and 1300°C. In the case of tile 300 x 300 x 20, the duration of firing is 20 hr., while it is about 10 times longer with furnaces using coal or fuel oil. M.V.C.

West Virginia coals—their classification and analyses. P. B. PLACE. *Combustion*, **9** [2] 27–32 (1937).—This is the concluding article covering the principal coal-producing areas in the U. S. H.E.S.

BOOK AND BULLETINS

Friability of Alabama coals. ELLIS S. HERTZOG AND JAMES R. CUDWORTH. *U. S. Bur. Mines Repts. Investigations*, No. 3384, 8 pp. Free. R.A.H.

Grindability of Alabama coals. ELLIS S. HERTZOG AND JAMES R. CUDWORTH. *U. S. Bur. Mines Repts. Investigations*, No. 3382, 8 pp. Free. A special study of some of the chemical and physical properties of Ala. coals is reported. R.A.H.

Linear Expansion of Various Ceramic Products between the Ambient Temperature and 1000°C. V. BODIN AND P. GAILLARD. Published by the Inst. Céramique Française. Reviewed in *Verre & Silicates Ind.*, 9 [9] 104 (1938).—The Chévenard differential dilatometer with mechanical registering was used. The phenomenon of expansion between 0° and 1000° is essentially reversible. No permanent transformations occur in this range. When examining the product to complete cooling, the needle comes back to zero except in the case of insufficient preliminary firing. Curves of heating and cooling, however, do not necessarily coincide, and when certain anomalies are more marked than others there is a so-called thermal hysteresis. The knowledge of cooling anomalies is of great practical importance since, if the danger zone is passed too rapidly, invisible fissures or cracks occur.

Curves of various samples of tile, faience floor tile, refractory products, silica brick, stoneware, porcelain, magnesia, and concrete were plotted. Fired clay and stoneware behave variably on cooling, necessitating special precautions. Products containing free silica have a critical expansion at about 210°C and 575°C. In furnaces operating intermittently, in which the temperature is over 550°, the refractory lining does not present the anomalies of quartz. Concrete has an expansion double that of refractory linings. M.V.C.

PATENTS

Apparatus for producing progressively delayed combustion. F. S. Bloom. U. S. 2,117,270, May 17, 1938 (June 29, 1935).

Gas burner. R. C. Dailey (Benjohn Labs., Inc.). U. S. 2,117,275, May 17, 1938 (June 20, 1934). Otto Lutherer (North American Mfg. Co.). U. S. 2,117,968, May 17, 1938 (April 25, 1934).

Kiln. J. T. Robson and G. R. Sylvester (Ferro Enamel Corp.). U. S. 2,117,994, May 17, 1938 (Feb. 4, 1937).

Reversible regenerative furnace. J. B. R. Brooke (John Lysaght, Ltd.). U. S. 2,115,613, April 26, 1938 (May 17, 1937).

Geology

Bauxite from Dreistätten in lower Austria. E. Dittler and O. Kuhn. *Verhandl. geol. Bundesanstalt*, **1936**, 233–37; *Chem. Abs.*, **32**, 2462 (1938).—New analyses of bauxite and serpentine are given. The bauxite contains 0.15% NiO, indicating an origin through the weathering of a mass of a basic rock.

Beneficiation of common clays. G. A. Bole. *Brit. Clayworker*, **47** [552] 21 (1938). R.A.H.

Chemical and mineralogical study of a new titanium mineral from Nellore. N. Jayaraman and K. R. Krishnaswami. *Proc. Indian Sci. Congr., 25th Congr.*, **1938**, Part 3, p. 117.—A detailed study of the mineral comprising the black magnetic inclusions in the garnets of the schist complex of Nellore has been conducted to ascertain its mineralogical and chemical significance. The microscopic and chemical data concerning the mineral are given and the methods employed are described. The chemical and mineral compositions are given in tables. They show a very high percentage of TiO_2 which is in excess of that required for normal ilmenite. The various hypotheses advanced to account for this excess of TiO_2 and for the existence of systems such as $FeTiO_3$–TiO_2, $FeTiO_3$–Fe_2O_3, $FeTiO_3$–Fe_3O_4, and $FeTiO_3$–Fe_2O_4–TiO_2 are discussed. From the more or less homogeneous nature of this mineral, its high titanium content, and its strongly magnetic property, the authors conclude that it is a well-defined type, probably belonging to a new system of minerals having the composition $FeTiO_3$–Fe_2O_4–TiO_2. A.P.S.

Chemical nature and formation of glauconite. I. Ya. Mikei. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **2**, 813–26 (1936); abstracted in *Chem. Zentr.*, **1938**, **i**, 2332.—The chemical composition, structure, properties, and formation of natural and synthetic glauconite are discussed. Glauconite is a homogeneous mineral with a typical layer lattice; an aluminoferric silicate is its basic component. M.V.C.

Clay. W. Bragg. *Proc. Roy. Inst. Gt. Brit., Advance copy*, Nov. 19, 1937, 33 pp.; *Chem. Abs.*, **32**, 3108 (1938).—B. discusses the structure of clays in relation to properties such as plasticity, base exchange, etc. Data, figures, and 11 references are given.

Clay minerals. C. H. Edelman. *Landbouwkund. Tijdschr.*, **49**, 358–77 (1937); abstracted in *Chem. Zentr.*, **1938**, **i**, 1748.—E. deals with (1) the definition of clay, (2) nature of clay minerals, (3) chief minerals found in clay, (4) base exchange of clay, and (5) crystalline nature. M.V.C.

Drying characteristics of a calcareous surface clay. R. K. Hursh and C. R. Filippi. *Bull. Amer. Ceram. Soc.*, **17** [5] 206–209 (1938).

Feldspar of Mount Beshtau (North Caucasus). A. P. Gerasimov. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **2**, 795–805 (1936); abstracted in *Chem. Zentr.*, **1938**, **i**, 2332.—Laccolite from Mount Beshtau, consisting of monoclinic and triclinic feldspar, hornblende, and pyroxene, is discussed. M.V.C.

Foshallasite of the Chibina tundra. P. N. Chirvinskiĭ. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **2**, 757–63 (1936); abstracted in *Chem. Zentr.*, **1938**, **i**, 2332.—Foshallasite, $3CaO{\cdot}2SiO_2{\cdot}3H_2O$, is a new mineral belonging to the zeolite group. Its characteristics are discussed. M.V.C.

Generalities on clays. Victor Charrin. *Argile*, No. 178 (Feb.), pp. 1–5 (1938).—V. discusses various types of clays and their origin, particularly clays formed from the disintegration of limestone and fuller's earths. M.V.C.

Geological conditions of diatomaceous earth deposits in the Czechoslovak Republic. Vojtěch Smetana. *Sbornik státního geologického ustávu Československé republiky* (*Almanac State Inst. Geol. Czechoslovak Republic*), **11**, 119–44 (1936).—Diatoms of soft-water origin predominate in Czechoslovakia. They are found (1) in the Bohemian Mesozoic rocks (at Bilina), especially tripoli and the so-called porous slate stone, (2) in the vicinity of Soos, Francisbad, and Marienbad, and (3) in the South Bohemian basins of Budweis and of Třebon. The latter deposits are as much as 13 m. in thickness and are of the greatest industrial importance. At Mydlovary they are used for the manufacture of porous brick and at Borovany, Ledenice, and their vicinities, for the manufacture of insulating ware (Calofrig). Other deposits of diatomaceous earths are found at Zvolen (tripoli) and at Bánská Bystrica. R.B.

Geology of British pottery materials. W. O. Williamson. *Trans. Ceram. Soc.*, **37** [2] 27–48 (1938).—W. discusses the genesis of British ceramic fluxes and clays from the standpoint of modern petrogenetic ideas. Both actual and potential supplies of these materials are mentioned. A bibliography is given. R.A.H.

Hydrothermal synthesis of kaolin. V. M. Permyakov. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **1**, 563–80 (1936); abstracted in *Chem. Zentr.*, **1938**, **i**, 1552.—Comparative thermal, optical, and, chiefly, X-ray

studies showed that Crimean nacrite is similar to the Saxonian nacrite. Nacrite was synthetically produced from air-dried hydrates of alumina and silica (ratio > 1:2) under pressure and in the presence of steam at 335° after 144 hr. Kaolinite and dickite can not be obtained under similar conditions. M.V.C.

Kyanite of the Kola Peninsula and the problems of highly refractory materials. P. A. Borisov. *Razvedka Nedr*, **1937**, No. 12, pp. 1–5; abstracted in *Chem. Zentr.*, **1938, i,** 1427.—The analysis and microscopic investigation of kyanite schist found in the central part of the Kola Peninsula showed its suitability for the manufacture of highly refractory products. M.V.C.

Magnesite deposits of central Europe. Jul Frank. *Tek. Tid.* [Bergsvetenskap], **67** [28] 55–60 (1937); abstracted in *Chem. Zentr.*, **1938, i,** 1325.—F. describes the large magnesite deposits of Austria, Tirol, and Germany and gives data on their composition and working methods. M.V.C.

Magnesite and dolomite deposits of the Krasnoyarskii region. N. Avlasenko. *Ogneupory*, **5** [7] 476–77 (1937).—A. describes two newly discovered magnesite and dolomite deposits in west Siberia; these deposits have a favorable composition and good technical properties. M.V.C.

Mineral wealth of Slovakia and its importance for the Czechoslovak, especially for the Slovak, industry. O. Kallauner. *Stavivo*, **1937**, p. 276.—Slovakia has deposits of raw materials for refractory ware at Lučenec, Poltár Pukonce, and Kalinov. A belt of magnesite 160 km. in length stretches from Lučenec and Lovinobáné over Hnuštu, Hořava, and Ochtina up to Bankov. Bauxite has been found at Mojtin. Plaster stone is found near Spíšská Nová Ves, Zablatice, Hanušovce, and Chocholné, asbestos at Dobšinné, graphite in the belt from Rimavské Baně to Jelšava, soft-water quartzite at Hrouský Svatý Kříž, hydraulic tuff at Hodejov, bacilloric earth at Doubravice, Jastarba, and Močiar, dolomite with asphalt at Varín, and opals at Dubuik, Herlan, and Dobšimé. Slovakia is also rich in ores. R.B.

Native raw materials for the ceramic industry. Istvan Csordas. *Vegyi Ipar*, **36** [20–21] 3–4 (1937); abstracted in *Chem. Zentr.*, **1938, i,** 1424. C. discusses the selection of raw materials for the ceramic industry of Hungary. M.V.C.

Nepheline syenite. T. T. Quirke. *Trans. Illinois State Acad. Sci.*, **29** [2] 179 (1936).—Chemical and mineral classifications are made of specimens of syenite obtained from Bigwood Township, Ontario, Canada. Rocks range from quartz bearing adamellite into nepheline-rich litchfieldite characterized by a general scarcity of dark constituents, by their content of soda-rich plagioclases and microperthite, and by an approximate balance in the amounts of potash and plagioclase feldspar. B.C.R.

Nepheline syenite—a new industrial mineral. C. M. Nicholson. *Can. Chem. Process Ind.*, **22**, 33–35 (1938); *Chem. Abs.*, **32**, 3109 (1938).—The nepheline and associated alkali syenites in Peterborough, Haliburton, and Hastings counties of central Ontario are extensive deposits. The deposit at the northern end of Stoney Lake consists almost entirely of nepheline syenite of great purity. Nepheline syenite contains 6% more Al_2O_3 and a somewhat higher total percentage of Na_2O+K_2O than feldspar, and its Fe content is only 0.06%. It may be used in various types of whiteware bodies and in semivitreous dinnerware bodies. It is employed in ground-coat sheet-steel enamels, in glasses, etc.

Origin of the clayey rocks near Confolens (Charente) ascribed to the siderolithic. F. Kraut and A. Vatan. *Compt. Rend.*, **206** [6] 443–45 (1938).—A thorough examination of the mineral deposits of quartz, feldspar, muscovite, and kaolin showed that they are not, as usually assumed, siderolithic sediments but a product of local changes of a crystalline substratum of an original lithologic nature. M.H.

Presence of Li, Rb, and Cs in basalts, granites, feldspars, and clay slates. Yu. M. Tolmachev and A. N. Filippov. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **1**, 203–21 (1936); abstracted in *Chem. Zentr.*, **1938, i,** 1748.—Tables summarizing the results of spectrographic analysis of these minerals located in the U.S.S.R. are presented. M.V.C.

Reactivity of lignite as important means for obtaining ceramic raw materials poor in iron. T. Schauer. *Sprechsaal*, **71** [5] 67–68 (1938).—The small amount of oxalic acid used in the deferrization of raw materials is not responsible for it; deferrization is often due to the reactivity of lignite in clays and quartz. M.V.C.

Refractory clays. R. Leduc. *Argile*, No. 178 (Jan.), pp. 7–9; No. 178 (Feb.), pp. 9–11; No. 179, p. 13 (1938).—L. presents the chemical composition of a number of refractory clays located in France. See *Ceram. Abs.*, **17** [4] 158 (1938). M.V.C.

Solubility of quartz. C. S. Fox. *Records Geol. Survey India*, **69** [4] 423–25 (1936).—Some quartzite pebbles from conglomerates in the Jharia coal field have been corroded under the action of surface waters. A.P.S.

Thermodynamical calculation of the solubility of some important sulfides up to 400°C. Jean Verhoogen. *Econ. Geol.*, **33** [1] 34–51 (1938).—The usual methods of physical chemistry were applied to the calculation of the solubility of sulfides up to 400°C. Results for ZnS, PbS, HgS, CuS, Ag_2S, and Cu_2S indicate a considerable increase of solubility with temperature, the ratio $\frac{\text{solubility at } 400°}{\text{solubility at } 25°}$ ranging from 10^2 to 10^4 and reaching 10^7 for ZnS. The order of increasing solubility remains the same at 400° as at 25°. A convenient formula has been developed for determining changes of solubility with changes in acidity. J.L.G.

Transformation of kaolin on heating. D. S. Belyankin and V. P. Ivanova. *Akad. Vernadskomu Pyatidesyat. nauchn. Deyateln.*, **1**, 155–62 (1936); abstracted in *Chem. Zentr.*, **1938, i,** 1552.—Kaolin undergoes two transformations on heating: (1) endothermic, at 500° to 550° (according to the heating curve) or 350° to 400° (according to the dehydration curve), and (2) exothermic transformation at 950° to 1000° (according to the heating curve), which is probably too high. The first transformation shows a dehydration of kaolin and a complete disintegration into a dispersed mixture of alumina and silica. The second transformation corresponds either to a combination of dispersed alumina and silica into mullite (sillimanite) with a separation of silica or to an exothermic crystalliza-

tion of alpha alumina, according to Insley and Ewell (*Ceram. Abs.*, **14** [8] 201 (1935)). They also state that a lasting firing of kaolin to 880° lowers the magnitude of the exothermic effect; the presence of alkalis in monothermite and montmorillonite minerals, which do not show any exothermic effect at high temperatures, has the same effect. M.V.C.

World resources of bauxite. VICTOR CHARRIN. *Céram., Verrerie, Email.*, **6** [1] 12–13 (1938).—C. reviews world bauxite deposits and their mining. M.V.C.

Zircon silicates in the Lowoser tundra. V. I. GERASIMOVSKIĬ. *Redkie Metally*, **6** [4] 42–43 (1937); abstracted in *Chem. Zentr.*, **1938, i**, 1748–49.—A new mineral containing ZrO_2, Nb_2O_5, and Ta_2O_5 was discovered in the Lowoser tundra. It is of a dark brown to black color, does not burn, and has a hardness of about 5. M.V.C.

BOOKS AND BULLETINS

Bureau of Mines and mineral utilization. JOHN W. FINCH. *U. S. Bur. Mines Information Circ.*, No. 6996, 6 pp. Free. F. stresses the importance and value of the country's mineral resources, their value in use, and the need for both technology and economies in the production and utilization of these resources. R.A.H.

Economic Geology of the Central Coal Field: Area I. T. ROBERTSON AND D. HALDANE. H. M. Stationery Office, Edinburgh, 1937. Price 3s 6d net. The chief materials of ceramic interest in the part of Dumbartonshire, Scotland, included in this volume are the fire clays (which are not thick enough to be of commercial importance) and the coals (which are fully described). The term shale in the Scottish coal fields is used only for bituminous or oil shale; other shales are known as blaes. A.B.S.

Marketing clay. PAUL M. TYLER. *U. S. Bur. Mines Information Circ.*, No. 6998, 10 pp. Free. T. describes the various kinds of clays, covering such properties as color, texture, and plasticity. Their commercial classification is given as well as sales in the U. S. in 1936 and a list of buyers of clay. R.A.H.

Marketing mica. PAUL M. TYLER. *U. S. Bur. Mines Information Circ.*, No. 6997, 8 pp. Free. T. discusses the kinds, grades, production, consumption, uses, prices, and markets for mica. R.A.H.

Mineral resources of Ohio. WILBER STOUT. *Geol. Survey Ohio Information Circ.*, 4th Ser., No. 1, 10 pp. (1938).

Purification of clay. S. R. DAS AND M. A. SABOOR. *Bull. Ind. Research Bur., Govt. of India*, No. 9, 7 pp. (1937). Price 8d. The authors describe experiments to determine the most suitable methods of colloidal peptization and flocculation and the optimum conditions under which the refining process could be operated with advantage on a clay from the Godavari River bed, which had been brought to their notice as being difficult to purify to the extent desired. They suggest the following process: (*a*) peptization of the clay with about 10 times its weight of a 0.16% solution of soda ash in soft water; (*b*) separation of sand from the peptized slip by settling for the requisite length of time; (*c*) drawing off of the supernatant peptized slip without disturbing the residue of sand settling below; (*d*) flocculation of the peptized sand-free slip by adding a strong solution of $CaCl_2$ containing as much $CaCl_2$ as soda ash contained in the slip (the mixture may then be allowed to settle overnight); (*e*) separation of the coagulated refined clay in the gel form by the removal of the supernatant water layer; and (*f*) drying the coagulated gelled clay, either by exposure to the sun or by the aid of artificial heat. For large-scale operations the principle of peptization can be effectively utilized in combination with elutriation as a continuous process. For this purpose a suitably designed counter-current tower of the type used in solvent extraction processes may prove quite useful. A.P.SOM

Report of the Committee on Sedimentation, 1936–37. Division of Geology and Geography, National Research Council, Washington, D. C. 128 mimeographed pages. Price 15¢. Reviewed in *Bull. Amer. Assn. Petroleum Geologists*, **22** [2] 223–24 (1938). G.M.H.

PATENT

Decomposition of titanium ores. I. J. KRCHMA (E. I. du Pont de Nemours & Co.). U. S. 2,112,966, April 5, 1938 (April 2, 1937). A process for the recovery of titanium values from titaniferous ores comprises initially adjusting attack of sulfuric acid by dilution and heating to controlled percentage concentration and elevated temperature and then slowly adding during a period ranging from 5 to 40 min. an excess amount of natural titaniferous ore to the heated acid.

Chemistry and Physics

Basic selenates and tellurates. G. GIRE AND F. FOUASSON. *Compt. Rend.*, **206** [5] 351–53 (1938).—By a reaction of selenite solution with Ni, a basic Ni selenate of the formula $SeO_3 \cdot 7NiO \cdot nH_2O$ was obtained. This salt decomposes slowly in water and in air. In a similar manner, basic cobalt selenates and a basic Ni tellurate of the formula $TeO_3 \cdot 2NiO \cdot nH_2O$ were obtained. M.H.

Coefficient of expansion of barium and calcium, and allotropy. P. G. CATH AND O. L. V. STEENIS. *Z. Tech. Physik*, **17**, 239–41 (July, 1936).—The expansion behavior of these elements was determined between 0° and 300°C. The expansion behavior is greatly influenced by the thermal treatment of the materials. Values of the coefficient of expansion for barium range from 170 to 210 $\times$ 10^{-7}. A discontinuity is encountered at 390°C, indicating the presence of two modifications. The coefficient of expansion for calcium amounts to 220 $\times$ 10^{-7}. W.M.C.

Determination of alkaline-earth metals. GEORGE WOLF. *Compt. Rend.*, **206** [6] 435–37 (1938).—Brill's method for the separation of Ca, Ba, and Sn in mixtures of the three salts was improved by operating in a vacuum; in this way the mixture of salts need be heated only to 630° to 840° instead of to 920° to 1170°. An example of the determination is given. M.H.

Disintegration of cryolite. M. S. BELETSKIĬ. *Legkie Metally*, **6** [4] 11–13 (1937); *Chem. Abs.*, **32**, 2448 (1938).—

X-ray examination shows that cryolite decomposes when heated in air to 1000°, owing to the oxidation of AlF_3 to β-Al_2O_3.

Distribution of solutes in silica gel. SUTTON REDFERN AND W. A. PATRICK. *Jour. Phys. Chem.*, **42** [4] 497–505 (1938).—A study was made of the distribution of KCl, KBr, NaCl, NaBr, LiCl, $MgCl_2$, $CaCl_2$, $SrCl_2$, $BaCl_2$, and dextrose between a hydrogel of silicic acid and the surrounding equilibrium solution. In all cases, the molal concentration of solute was less inside the gel than outside. Calculations showed that the amount of bound water decreased as the silica content of the gel increased. No correlation was found between the activity of the water and the quantity bound. The general results could not be satisfactorily explained on the basis of bound water, adsorption, or Donnan equilibria. 20 references.

C.J.P.

Evaporating the water with burning alcohol as a rapid means of determining moisture content of soils and of molding sands. G. J. BOUYOUCOS. *Bull. Amer. Ceram. Soc.*, **17** [5] 203–206 (1938).

Generalized equation of heat conduction. M. RAZUIDDIN SIDDIQI. *Indian Jour. Phys.*, **9**, 299–310 (1935).—Solution is sought of the nonlinear equations of heat conduction for nonhomogeneous bodies, *i.e.*, of

$$\frac{\partial}{\partial x}\left\{p(x)\frac{\partial U}{\partial x}\right\} - \frac{\partial U}{\partial t} = U^2$$

with boundary conditions

$$U(0, t) = U(\pi, t) = 0 \text{ for all } t \geq 0$$
$$U(x, 0) = f(x) \text{ for all values of } x \text{ between } 0 \text{ and } \pi.$$

The solution $U(x, t)$ is determined in a series of Strum-Liouville characteristic functions:

$$U(x, t) = \sum_{x=1} v_n(t)\ \phi_x(v).$$

The problem of determining the coefficients $v_n(t)$ leads to an infinite system of nonlinear integral equations which is solved by the method of successive approximations developed by S. The uniqueness of the solution is proved.

A.P.S.

Solubility of the oxides at 1200° in molten boric anhydride. M. FOEX. *Compt. Rend.*, **206** [5] 349–50 (1938).—Experiments indicate that the solubility of the oxides varies regularly with the molecular weight. Five groups of oxides, of the form X_2O, XO, X_2O_3, XO_2, and X_2O_5, were investigated. Some oxides formerly considered insoluble in boric anhydride at 1200°C have shown considerable solubility. M.H.

Starting of the flow in a viscous liquid. H. PONCIN. *Compt. Rend.*, **206** [2] 94–96 (1938).—P. gives a theoretical investigation of transverse and laminar flow in a viscosimeter. M.H.

Temperature rise in material of which the thermal properties vary with temperature. J. H. AWBERY. *Proc. Phys. Soc.* [London], **48**, 118 (1936).—The partial differential equations governing the flow of heat in a medium for which the thermal conductivity and volumetric specific heat vary parabolically with temperature are reduced to an ordinary differential equation when the medium is semi-infinite in extent. The equation is solved exactly where the two properties vary proportionally to each other and approximately, for the general case, in powers of $x/\sqrt{(2t)}$, where x is the distance from the hot face and t is the time. An illustration is given for a brick material.

L.E.T.

X-ray spectrographic determination of lanthanum, neodymium, and gadolinium in the presence of other rare earths. KENJIRO KIMURA. *Bull. Chem. Soc. Japan*, **13** [1] 10–27 (1938). G.M.H.

BOOK

Graphs and Calculations in Ceramics. RUDOLF BARTA AND KÁREL ŠANDERA. *Spisy Masarykovy Akademie Práce*, **46** (1937). 115 pp., 49 illustrations. Chapter headings are as follows: (1) practical application of mathematical methods: (*a*) organization of laboratory and working regulations, (*b*) limits of the exactness and reliability of technical calculations, (*c*) theory of correct sampling and measuring, (*d*) traffic statistics and mathematical plant analysis; (2) simplification of mathematical calculations: (*a*) elementary calculations, (*b*) logarithmic tables, (*c*) general tables; (3) calculating rules and machines: (*a*) slide rule, (*b*) special rules, (*c*) calculating machines; (4) graphical calculation: (*a*) the principle and its practical application, (*b*) general rules, (*c*) practical examples; (5) addenda; and (6) review of literature. R.B.

PATENTS

Alkali silicates. E. ÖMAN. Swed. 89,873, Aug. 3, 1937; *Chem. Abs.*, **32**, 2694 (1938).—Steam is caused to act upon an alkali-metal chloride in the presence of SiO_2 or an acid silicate, and a weight-ratio of more than 1:1 and preferably 2:1 is maintained between the alkali-metal chloride and the total SiO_2 during the whole of the reaction period.

Alkali silicates. E. ÖMAN. Swed. 89,874, Aug. 3, 1937; *Chem. Abs.*, **32**, 2694 (1938).—Alkali silicates are prepared by the interaction of alkali-metal chloride, SiO_2, or an acid silicate and steam. The alkali-metal chloride vapor, which is present during the whole of the reaction period, is partly condensed and in condensed form caused to act on the other reagents. To this end a higher temperature, *i.e.*, a higher partial pressure of alkali-metal chloride, is maintained in the prereaction zone than in the reaction zone itself. Apparatus is described.

Making alkali subsilicates. PENNSYLVANIA SALT MFG. CO. Brit. 482,698, April 13, 1938 (Sept. 17, 1936).

Making red pigment. J. J. O'BRIEN AND G. M. JUREDINE (Glidden Co.). U. S. 2,115,080, April 26, 1938 (Feb. 11, 1935). The method of making cadmium-selenide red comprises dissolving selenium in a solution of a soluble sulfide of approximately 16° to 20° Bé in an amount sufficient to produce a solution of approximately 18° to 28° Bé, separating the impurities from the selenium solution within 24 hr. after the solution is prepared at a temperature of 100° to 190°F, precipitating crude pigment by adding a cadmium salt solution to the clarified solution, and calcining the crude pigment.

Producing granular borax. H. D. HELLMERS. U. S. 2,115,771, May 3, 1938 (Jan. 29, 1934).

Separating lead and cadmium from zinc ores. R. W.

HYDE (Dwight & Lloyd Sintering Co., Inc.). U. S. 2,116,203, May 3, 1938 (April 21, 1937).

White lead and method of production. E. D. TURNBULL (Glidden Co.). U. S. 2,115,090, April 26, 1938 (June 3, 1936).

Zirconium compounds. I. YA. BASHILOV. Russ. 45,283, Dec. 31, 1935; *Chem. Abs.*, **32**, 3102 (1938).—Zr ore is treated with strong acid, and a reagent containing P_2O_5, such as apatite, is added to the solution. Zr phosphate is precipitated and can be worked up into desired compounds.

General

Boiler inspectors meet at New York. ANON. *Combustion*, **8** [12] 35–37 (1937).—A review is presented of some of the papers dealing with the A.S.M.E. Boiler Code changes, forced-circulation boilers, design and operation of large high-pressure steam-generating units, prevention of furnace explosions, and various aspects of welding pressure vessels and of welding alloy steels. H.E.S.

Character of dusts liable to produce silicosis. J. W. MATTHEWS. *Chem. Age* [London], **38** [981] 307 (1938).—Two methods have been devised for collecting dusts without contact with water: (1) filtering the air by drawing it through a layer of salicylic acid crystals, and (2) drawing the air through a labyrinth of baffles in which fractional deposition occurs. The smaller particles of siliceous material are much more hygroscopic than the larger particles, and much of the silica is soluble in water. Dusts which cause silicosis, *e.g.*, calcined flint and asbestos, yield 12 to 30 mg./g. of silica to 100 ml. of water, but cement and sillimanite dusts (which are regarded as innocuous) yield only 1 mg. Admixture with an equal weight of lime greatly reduces the quantity of silica soluble in water. A.B.S.

Circulation in boiler tubes. K. TOENSFELDT. *Combustion*, **9** [2] 24–26 (1937).—Curves representing densities, velocity heads, available heads, and losses, as well as velocity and weight ratios, are presented, showing the trends to be encountered and serving as a guide in analyzing the circulation within a water-tube boiler. H.E.S.

Evaporators and their applications. R. D. SPEAR. *Combustion*, **9** [2] 19–23 (1937).—Evaporators have contributed to the development of the modern high-pressure steam boiler by furnishing a safe, dependable supply of distilled water make-up. S. reviews the conditions leading to the extensive use of evaporators in modern high-pressure plants and gives and discusses flow diagrams of typical arrangements used in large plants of different industries. H.E.S.

Excretion of silica in urine after oral administration of silica and silicate dusts and the solubility of silica and silicate dusts in acid and alkaline solutions at 37°C. A. G. R. WHITEHOUSE. *Jour. Ind. Hyg. & Toxicol.*, **19** [10] 590–97 (1937).—The excretion of silica in human urine after swallowing doses of silica and/or silicate dusts, precipitated silica, and silicic acid solution was measured. The daily excretion of silica was definitely increased with very fine flint dust, a silicate dust, and precipitated silica; in the case of silicic acid solution, the increase was much greater. The rate of solution of some silica and silicate dusts in acid and alkaline solutions at 37° was determined. The amount of silica dissolved by $N/10$ NaOH was greatest with flint; lower values were obtained from quartz, coal-measure sandstones, granite, and whinstone, while a sample of stone dust gave the lowest. With $N/10$ HCl as solvent, the dusts were soluble in the following order: whinstone, granite, sandstones, quartz, and flint. The amount of silica dissolved from flint by $N/5$ Na_2CO_3 was much greater than that by $N/10$ NaOH, while the reverse was true with granite. The influence on the rate of solution of such factors as the particle size and the ratio of dust to solvent is shown. The daily excretion of silica in urine is influenced by diet, particularly if the silica is ingested in such a state that it is readily absorbed, *e.g.*, as in beer, water, etc. In view of these facts, great care should be exercised in attempting to correlate urinary excretion of silica with silicosis. See "Urinary—," *Ceram. Abs.*, **14** [9] 235 (1935). E.J.V.

Franklin Institute. V. V. KELSEY. *Bull. Amer. Ceram. Soc.*, **17** [5] 227–28 (1938).

Importance of production statistics. N. RUDOLF. *Sborník na počest průmyslníka F. Slavíka* (*Almanac in Honor of F. Slavík*), **1936**, p. 15.—In Slavík's works at Hrochovo Týnec, Žihle, and Tuněchody, numerical and (biweekly) graphical reports are made concerning losses in drying sheds, kiln loading, losses in the kiln, second-grade goods, consumption of fuel in firing, cost of steam, consumption of steam per 1000 pieces, consumption of electric current, and cost of driving power. Numerical calculations only are made of production in the pressroom, waste at the presses, time waste at the presses, working capacity of the boilers, evaporation of coal, losses in condensed water, output of the electrical plant, and consumption of purchased electric current. The following data (dispensed with because of economical reasons) were formerly ascertained: (*a*) in the pressroom: contents of coarse constituents in the clay mixture and contents of water and its temperature; (*b*) in the drying shed: course of temperatures, heat consumption for the evaporation of 1 kg. of water, amount and temperature of kiln air, output of evaporated water measured in kg., course of losses in the chamber, and technological properties of roofing tile, *i.e.*, permeability, porosity, and weight. The results of these studies are reported to the workmen to promote a coöperative spirit. R.B.

Lead and silicosis: factory precautions. D. F. W. BISHOP. *Trans. Ceram. Soc.*, **37** [1] 17–26 (1938).—B. deals with the points or processes in which the most common dangers lie and the practical precautions which can be taken. R.A.H.

Liability of employers. L. T. PARKER. *Combustion*, **9** [1] 23 (1937).—Various courts have held that an employee is bound to obey the order of his employer unless the command includes a violation of the law or the act required is so obviously dangerous that no employee of ordinary prudence would undertake to perform it. When the employer gives the order and the employee obeys it

and is injured as a consequence thereof, the employer is liable. According to the law, if an employee is injured by conduct of a fellow employee speaking for the employer, the employer is liable. No employer, either under the Workmen's Compensation Laws or in a damage suit filed by an employee, is liable for an injury sustained by an employee who acts outside the scope of the employment. An injury is received "in the course of the employment" when the workman is doing the duty which he is employed to perform. An injury is received "out of employment" when there is apparent to the rational mind, upon consideration of all the circumstances, only a casual connection between the conditions under which the work is required to be performed and the resulting injury.

H.E.S.

Menace to coal industry. R. E. Howe. *Combustion*, **9** [2] 18 (1937).—The disastrous effect to the coal industry of any large-scale hydroelectric program is self-evident. In the territory embracing eastern Ky., eastern Tenn., southwestern Va., and southern W. Va., the coal operators spend annually over 105 million dollars, of which 68 million is for wages, 34 million for mine and commissary supplies, and 3 million for federal, state, and county taxes. Industries which receive a large share of the miners' dollars and other lines of business dependent upon the coal industry for equipment orders are also threatened when hydroelectric power threatens bituminous coal.

H.E.S.

Report of the activities of the Experimental Institute for the Silicate Industry at the Czech Technological Institute in Brno, 1936. Anon. *Stavivo*, **1937**, p. 140.

R.B.

Report of Committee on Patents. F. M. Feiker. *Bull. Amer. Ceram. Soc.*, **17** [5] 229–36 (1938).

Requirements for an engineer. J. M. Drabelle. *Combustion*, **9** [2] 26 (1937).—The greatest essential for an engineer is the ability to convey his knowledge to others, to gain their coöperation, and to maintain discipline in his organization not by fear but by commanding respect.

H.E.S.

Security of employment in the engineering profession. Anon. *Combustion*, **9** [1] 27 (1937).—A digest of a report by the U. S. Department of Labor, based on a survey covering more than 35,000 engineers is given; means used to secure employment, contract and civil service protection, patent privileges, and pension protection were investigated.

H.E.S.

Steam-generating unit carries Morris Paper Mills load. J. A. Reitzel. *Combustion*, **9** [2] 16–18 (1937).—A bent-tube boiler, fired with a traveling grate stoker burning local Illinois coal, carries the entire paper mill load, formerly handled by several smaller units, and has effected a 25% saving in fuel. The unit has been in continuous operation for more than six months and has shown an availability factor of 97.6%. Test results are given.

H.E.S.

Technique of testing. Charles A. Drake and Holger D. Oleen. *Factory Management & Maintenance*, **96** [3] 71–78 (1938).—A system of testing and rating prospective workers for the type of job they are fitted to fill is described.

J.L.G.

Training of unskilled labor. A. Stephenson. *Engineering*, **145** [3768] 347 (1938).—The usual method of training new employees by allowing them to watch an experienced workman is unsatisfactory, as too much dependence is placed upon the recruit being a good observer and the workman a good model. A more satisfactory procedure consists in first teaching the recruit the simplest movements involved in the operation and then proceeding step by step through the entire process. Correct habits are thus established before actual work has started.

B.C.R.

BOOKS AND BULLETINS

Annual report of Explosives Division, fiscal year 1937. Wilbert J. Huff. *U. S. Bur. Mines Repts. Investigations*, No. 3383, 33 pp. Free. H. discusses investigations on inflammability of gases and vapors, kinetics and mechanism of gaseous explosions, researches on explosives and on Diesel engines underground, chemical and physical tests of explosives, and blasting devices.

R.A.H.

Effect of angle of drilling on dust dissemination. Carlton E. Brown and H. H. Schrenk. *U. S. Bur. Mines Repts. Investigations*, No. 3381, 7 pp. Free. Results are given of tests made at Butte, Mont., to determine whether the angle at which a hole is drilled affects the amount of dust disseminated into the air during wet drilling.

R.A.H.

Methods for protection against silicosis and when they are justified. D. Harrington. *U. S. Bur. Mines Information Circ.*, No. 6989, 9 pp. Free. H. suggests methods for overcoming the formation of dusts in industry and for minimizing the effects of breathing industrial dusts.

R.A.H.

Proceedings of the Fortieth Annual Meeting of the A.S.T.M., Vol. 37, 1937: I, Committee Reports and Tentative Standards, 1365 pp. **II, Technical Papers,** 707 pp. American Society for Testing Materials, Philadelphia, Pa. Price $11.

R.A.Heindl

Relation of dust concentration to depth of hole during wet drilling. J. B. Littlefield and H. H. Schrenk. *U. S. Bur. Mines Repts. Investigations*, No. 3369, 5 pp. Free. Research to determine the concentration of dust in air during the complete cycle of operation in wet drilling is discussed.

R.A.H.

Results of recent research on the control or prevention of silicosis. D. Harrington. *U. S. Bur. Mines Information Circ.*, No. 6994, 8 pp. Free. H. gives results of research on silicosis control by the Bureau of Mines and other agencies and forecasts some of the things that may be done to reduce prevalence of dust diseases in the future.

R.A.H.

PATENTS

Ceramic. J. W. Whittemore and C. R. Oberfell (Mead Corp.). Can. 372,655, March 22, 1938 (Jan. 21, 1936; in U. S., Feb. 4, 1935). In the formation of clay products or like materials, the step comprises distributing through the clay, while in a plastic condition, a predetermined small quantity of a mixture of commercial salt and chestnut extract containing tannin.

G.M.H.

Ceramic mixtures. L. Bonnet. Brit. 480,982, March 16, 1938 (Dec. 12, 1935).

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Vol. 21, No. 7, Journal, pp. 239-266 THE JOURNAL and CERAMIC ABSTRACTS, JULY, 1938